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Cover Photograph: Western Tragopan
Tragopan melanocephalus
By John Corder

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METHODS OF CAPTURE AND RADIO TRACKING OF WESTERN TRAGOPAN *TRAGOPAN MELANOCEPHALUS* J.E. GRAY 1829 IN THE GREAT HIMALAYAN NATIONAL PARK, INDIA[1]

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Attempts were made to capture and radio track the Western Tragopan (*Tragopan melanocephalus* J.E. Gray 1829) in the Great Himalayan National Park, Himachal Pradesh, India. Leg-hold snares and automated fall nets were used to trap the birds. During the intensive efforts of 6,694 trap hours, one female Western Tragopan and 12 other bird species were captured. The trapped Western Tragopan was radio-tagged with necklace collar and was tracked for six months. Using 72 radio locations and Minimum Convex Polygon Method, the estimated home range was 31.6 ha, and it was 20.5 ha for summer and 4.7 ha for autumn. The bird showed preference for high tree cover, thick undergrowth of montane bamboo, high litter cover and perennial water sources. In addition, much of the findings on its ecology broadly corroborated with the earlier observations, suggesting that in spite of a very low sample size, credible information could be gathered through radio tracking and data collection at a finer scale. This study still remains the only investigation involving trapping and radio tagging of the Western Tragopan anywhere in the world. We recommend that the approach and methods adopted in this study be taken forward for not only the Western Tragopan, but also for other ground dwelling birds with similar habits, for generating decisive ecological information and subsequent conservation planning for these species.

Key words: Habitat use, Himalayas, home range, live trapping, pheasants, telemetry

INTRODUCTION

The Western Tragopan (*Tragopan melanocephalus* J.E. Gray 1829) is among the rarest pheasant species, confined to the temperate region of the north-west Himalaya in a narrow belt between Swat catchments in the North West Frontier Province, Pakistan and western Uttarakhand in India (Fuller and Garson 2000; BirdLife International 2001). With only 2,000-3,000 sq. km area of potential habitat available, its world population size is precariously low, with arguably much fewer than 5,000 individuals distributed in five fragmented populations (Gaston *et al.* 1983a; Johnsgard 1986; BirdLife International 2001). This population estimate obtained 25 years ago was based on limited records and is still to be validated. Even a review on the current status using empirical evidences, which is an urgent need, is unlikely to project a better population status, as habitat degradation, poaching and rampant use of habitat for minor forest produce collection continue to affect the species (Fuller and Garson 2000). On the other hand, attempts to evolve conservation strategies have been greatly constrained by inadequate scientific data on its habitat requirements and other life history traits. Prior to this study, the six months study by Islam (1985) in Pakistan was the only intensive effort to study the ecology of the species. Rest of the attempts were of short-term surveys primarily aiming at spatial distribution and population status of the species (Mirza *et al.* 1978; Islam 1982; Gaston *et al.* 1983b; Duke 1990; Pandey 1994; Jandrotia *et al.* 1995; Jandrotia *et al.* 2000; Whale 1996; Nawaz 1999). Ecological inferences from these efforts were constrained by low sighting records, attributed to low population density compounded with elusive behaviour of the bird. Therefore, even with these hard efforts, our understanding of the species biology remained obscure.

Systematic monitoring of adequate number of radio-tagged birds was an option to study and draw definite inference on the species biology. Moreover, the information on home range and movement pattern for such a threatened species are critical to estimate potential habitat and population size at a regional scale. Therefore, attempts were made to capture and radio-tag at least six individuals of the Western Tragopan in the Great Himalayan National Park (GHNP), which is one of the few strongholds for this species in India. The number was originally kept to a minimum of six considering the cost involved and threatened status of the bird, and that the number was to be increased once these six tags were successfully deployed. In this paper, we present the methods adopted to live trap the Western Tragopan, trap efficiency, ecological observations on the radio-tracked bird and suggestions for possible improvement of such studies in the future.

MATERIAL AND METHODS

Study site: The study was carried out from April to November 1999 in GHNP, which is situated about 40 km east of Kullu town in the state of Himachal Pradesh, India (31° 33'-31° 56' N; 77° 17'-77° 52' E). It covers an area of 754.4 sq. km constituted by four major watersheds – Tirthan, Sainj, Jiwa and Parvati, all of these form a part of Beas catchments. The altitude ranges from 1,344 to 6,248 m, representing diverse vegetation types from subtropical forests to alpine meadows. Tirthan valley of this Park became a natural choice for this study, since this effort was merely an extension of an already ongoing intensive research on habitat ecology of three sympatric pheasants, including the Western Tragopan, which began in April 1997. The logistics and infrastructure had already been established in this area by the intensive research project, besides the field experiences in the last few years enabled us to plan the study appropriately (Ramesh 2003).

Traps and trapping: Trapping was attempted using fall nets (N = 6) and leg-hold noose (N = 9), between April and June 1999. The fall net was a combination of 'automatic fall net' and 'walk-in trap' described by Bub (1991). The nets were considerably large, 15 to 18 m long, 6 m wide with a mesh size of 40 x 40 mm. All the nets were coloured black and dark green, to provide a camouflage effect. The nets were placed in such a way that 3 m of the net was set lying on the ground and the remaining 3 m standing at 50° angle supported by triggers which, in this case, were bamboo sticks (Fig. 1). The net would fall down upon the release of the trigger when disturbed by the bird while walking into the trap. Leg-hold noose is an indigenous trap method used by local people to trap large birds in some parts of north India.

The leg-hold noose has a series of 40-50 independent nooses fixed at 15 cm interval on a thin but strong rope (Fig. 2). The noose was made up of nylon and measured 30 cm in diameter, and was fixed with a bamboo at the base of the noose. The stick, which in this case was 10 cm long and of 2 cm girth, was pressed into the soft soil, leaving only

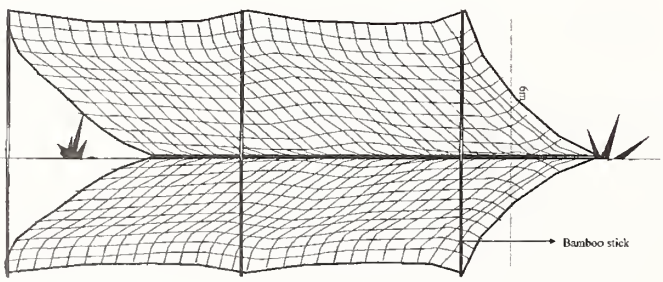

Fig. 1: Diagrammatic representation of fall net

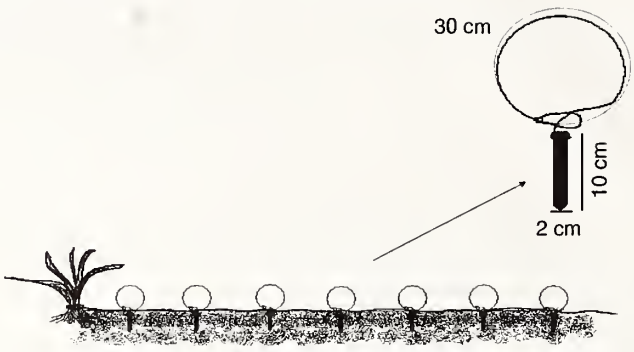

Fig. 2: Diagrammatic representation of leg-hold noose

the noose part on the ground sticking out at 90° angle. One end of the trap was tied to a nearby pole or a shrub that could hold back the trap when the trapped bird tries to pull away, where as the other end is left loose. This set up prevents the bird from breaking away from the trap, while enabling the bird to move around without inflicting any sort of damage to its leg.

Traps were set in 12 locations representing different forest types (n = 6), *thatches* (forest clearing used as livestock camps) (n = 2) and *nullahs* (small streams of both perennial and seasonal) (n = 4). A total of 6,694 trap hours, constituted by 3,927 net hours and 2,767 noose hours, were spent during the entire trapping sessions. These efforts were distributed disproportionately in the above three locations, with relative preference for locations regarded to yield better trap success. Correspondingly, the entire trap efforts represent 1,783 trap hours (953 net hours and 830 noose hours) in forest, 815 trap hours (501 net hours and 314 noose hours) in *thatches* and 4,096 trap hours (2,473 net hours and 1,623 noose hours) in *nullahs*. The traps were placed on the ground at previously identified sites such as water holes, roost sites and daily movement area, which were monitored periodically. Besides this, on locating or hearing the bird, the fall net was set up at 200 m away from the bird on the uphill and 3-4 persons, forming a semicircle, would slowly drive the bird towards the net. A total of 256 man-days (4 persons x 64 days in three months) were spent in the altitudinal range of 2,600-3,000 m, where relatively high concentration of the Western Tragopan was sighted during the three years of fieldwork.

Tagging and telemetry: The trapped bird was fitted with a necklace type (Biotrack) radio transmitter weighing about 50 gm, which had a potential life span of over 12 months. Triangulation method (Kenward 2001) was preferred over home-in method after testing the method for three consecutive sampling days. It was found that during the home-in method, the movement of the bird was found to be influenced by the observer while zeroing-in. Radio locations were recorded once in three sampling time sessions

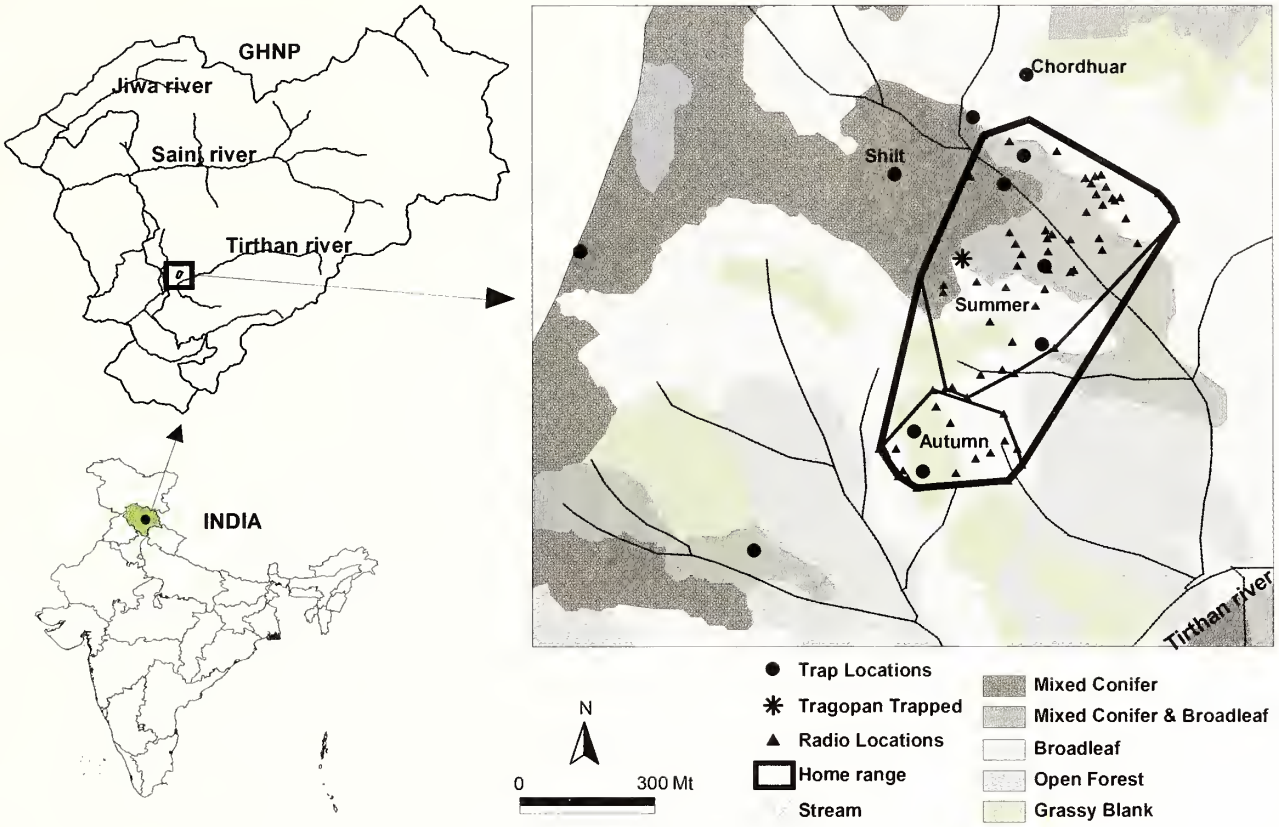

Fig. 3: Trapping location and home range of the radio-tagged female Western Tragopan

(6-11 hrs, 10-15 hrs and 15-18 hrs) every third day. The bird was radio-tracked until November 1999 covering both summer (May-September) and autumn (October-November) seasons, after which there were no signals received from the bird, and the reasons could not be ascertained. Locations were physically plotted on 1:50,000 scale topographic map and the home ranges were estimated based on the Minimum Convex Polygon (MCP) method using GIS software Arc/info and ArcView Animal Movement Extension. Spatial data developed for GHNP by the Wildlife Institute of India on

Table 1: Frequency and number of bird species caught in different traps

S. No.	Species	Frequency	Total number	Trap
1	Common Hill-Partridge (*Arborophila torqueola,* A. Valenciennes, 1826)	3	4	Net
2	Western Tragopan (*Tragopan melanocephalus,* J.E. Gray, 1829)	1	1	Noose
3	Koklass Pheasant (*Pucrasia macrolopha,* R.P. Lesson, 1829)	1	1	Net
4	Black-naped Green Woodpecker (*Picus canus,* J.F. Gmelin, 1788)	1	1	Noose
5	Spotted Scops-Owl (*Otus spilocephalus,* E. Blyth, 1846)	1	1	Net
6	Eurasian Woodcock (*Scolopax rusticola,* Linnaeus, 1758)	3	4	Net
7	Spotted Nutcracker (*Nucifraga caryocatactes,* Linnaeus, 1758)	1	2	Net
8	Blue Whistling-Thrush (*Myphonus caeruleus,* G.A. Scopoli, 1786)	2	2	Net
9	Plain-backed Thrush (*Zoothera mollissima,* E. Blyth, 1842)	1	1	Noose
10	Scaly Thrush (*Zoothera dauma,* J. Latham, 1790)	2	2	Noose/Net
11	Mistle Thrush (*Turdus viscivorus,* Linnaeus, 1758)	2	2	Net
12	White-collared Blackbird (*Turdus albocinctus,* J.F. Royle, 1840)	1	1	Net
13	Black-and-Yellow Grosbeak (*Mycerobus icterioides,* N.A. Vigors, 1831)	2	3	Net
	Total	21	25	

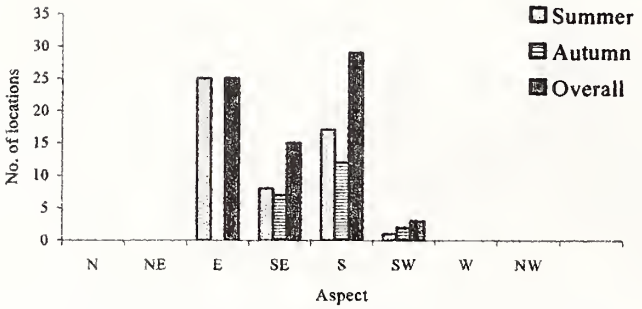

Fig. 4: Radiolocations recorded in different aspect categories

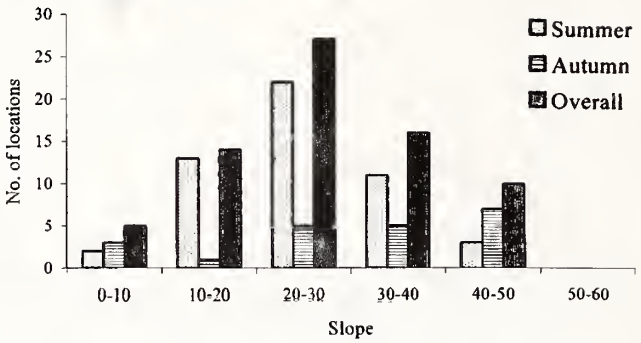

Fig. 5: Radiolocations recorded in different slope classes

vegetation (using IRS-LISS III satellite data), digital elevation model, aspect and slope were used to study the different habitat parameters used by the bird. Random plots (n = 9) of 10 m radius for tree layer, 5 m radius for shrub layers and 1 x 1 m quadrate for ground parameters, were sampled to describe microhabitat features within the home range area. The data collection on the microhabitat features was restricted to only summer season due to time constraints.

RESULTS

Trap success and home range: One female Western Tragopan was caught on May 14, 1999, in a leg-hold noose placed in a *nullah* within a Mixed Conifer and Broadleaf Forest above Grahani *thatch* in the Tirthan valley (Fig. 3). The bird weighed 1.25 kg, and the body length, wing length, wingspan and tail length were 40 cm, 20 cm, 70 cm and 28 cm respectively. During the course of trapping, 12 other bird species including Koklass *Pucrasia macrolopha*, Hill Partridge *Arborophila torqueola* and Eurasian Woodcock *Scolopax rusticola* were also caught, mostly in nets (Table 1). A total of 72 radiolocations representing summer (51 locations) and autumn (21 locations) seasons were obtained. The home range estimated from these locations was 31.6 ha, and it was 20.5 ha for summer and 4.7 ha for autumn months. Since MCP calculated the home range based on outer extreme points, the overall home range estimate also includes the area outside of the summer and autumn home ranges, therefore providing larger estimate than a simple addition of summer and autumn estimates (Fig. 3). The elevation of the home range area ranged between 2,440 m and 2,800 m, however, the bird was mostly restricted to 2,500-2,700 m in summer and between 2,440 and 2,530 m in autumn. The bird moved to a lower elevation between Rolla and Dulunga *thatch* in October and remained there till the signal reception got discontinued in late November. The bird frequented the east, south-east and south facing aspects during summer, while it totally avoided east facing aspect in autumn (Fig. 4), possibly as a response to high cold condition and snow cover in this particular east facing aspect. Use of slope category in summer was unimodal with bell-shape curve as typical of normal distribution, suggesting preference for moderate slopes, but used steeper slopes in autumn (Fig. 5), again perhaps to use areas devoid of snow cover.

Habitat use: The radio-tagged bird used five vegetation types, namely Mixed Conifer Forest, Mixed Conifer and Broadleaf Forest, Broadleaf Forest, Open Forest, and Grassy Blanks (Fig. 4), and did not venture into the remaining two types, alpine scrub and meadows that were represented in the study area. Of the 72 locations, 42 locations (58%) were in Broadleaf Forest followed by 21 locations (29%) in Mixed Conifer and Broadleaf Forest. Mixed Conifer and Broadleaf, and Broadleaf Forests were used relatively in higher proportion in summer, while in autumn, the bird used only the Broadleaf Forest and Grassy Blanks (Table 2). The proportion of different vegetation types within the home range and the corresponding number of radio locations suggests that habitat use by the bird was generally in proportion to availability, but had higher usage in Grassy Blanks, and avoided the Open Forest (Table 2). The Conifer Forests used by the bird were dominated by *Abies pindrow* and *Taxus baccata*. The Broadleaf Forests in higher altitude were dominated by *Acer caesium* and *Quercus semecarpifolia* and the lower altitude forests by *Juglans regia, Ulmus wallichiana*

Table 2: Area (in ha) of different vegetation types within the home range area during summer and autumn (radiolocations are given in parentheses)

Vegetation types	Summer	Autumn	Overall
Mixed Conifer	3.7 (4)	0.0 (0)	3.8 (4)
Mixed Conifer and Broadleaf	7.8 (21)	0.0 (0)	8.7 (21)
Broadleaf	7.6 (25)	2.8 (17)	13.1 (42)
Open Forest	0.0 (0)	0.0 (0)	1.2 (0)
Grassy Blanks	1.5 (1)	2.0 (4)	4.8 (5)
Overall	20.6 (51)	4.7 (0)	31.6 (72)

and *Corylus colurna*. The tagged bird used areas with high tree density (8.4 ±1.2 SE/plot) and shrub density (8.7 ±1.5 SE/plot), and interestingly, the shrub species in all the nine plots was dominated by montane bamboo *Thamnocalamus spathiflorus*. The home range had moderate tree canopy (30% ±1.9 SE) and perennial water sources. The litter cover and litter depth in the plots were 77.8% (± 3.2 SE) and 1.5 cm (± 0.08 SE) respectively.

DISCUSSION

Despite our intensive attempts, trap success for target species was limited to one, but capturing of a significant number of other birds, including the Koklass and Hill Partridge, in these traps suggests that the low trap success for Western Tragopan may not be related to trap efficiency. With such a low sample size, subsequent analysis and interpretation was restricted to descriptive data and any test statistics (e.g. chi-square) was considered unlikely to reflect the biological significance of the species-habitat relationship (Johnson 1999; Krebs 2000). Similarly, due to low sample size, the analysis related to home range estimation was confined to 100% Minimum Convex Polygon (MCP) method, rather than using more robust methods.

Interestingly, the empirical data collected on the habitat use by Western Tragopan in Pakistan (Islam and Crawford 1987) and the recent study in India (Ramesh 2003) have had similar observations on the way different habitat features such as vegetation types, altitude, canopy and shrub cover used by this species. Specifically, the radio-tagged bird proved important to substantiate the general claim of dense undergrowth such as high altitude montane bamboo being the important cover species for Western Tragopan, which in other parts of its range including Pakistan is the *Viburnum* sp. Further, the intensity of use of bamboo patches was largely overlooked by the conventional studies using trails monitoring calling behaviour (Ramesh 2003). This is the only known home range estimate for this species, and is also comparable with the estimates obtained for Cabot's Tragopan *Tragopan caboti* in China during the winter of 1987 (Young *et al.* 1991) and spring 1992 (Changqing and Guang-mei 1993), which were also based on a single female bird. The comparison of the results with other studies might not be directly comparable given the difference in species natural history and conditions, nonetheless, provide an insight on the pattern exhibited by congeneric species.

Though trapping of Western Tragopan was highly challenging, the experiences during the trapping operation suggested that with modifications to suit local conditions and appropriate placement of the traps, it would greatly increase the trapping success. The traps used in the study were found to be safe and effective, which was evident from the trapping of several other ground birds. It was also realized that instead of concentrating our efforts in one area, more trapping parties should have been used to trap the bird from different areas. Another possibility of increasing trap success would be to try trapping just after monsoon, when the population size is generally high after the breeding or try baiting in peak winter when the birds descend to a narrow belt in the lower altitude areas due to resource crunch (both food and habitat) caused by winter snow at higher altitudes (Johnsgard 1986; del Hoyo *et al.* 1994; Ramesh 2003). The selection of spring for trapping appears to have two major disadvantages; 1) the birds had dispersed in wider areas and 2) trapping could cause stress in breeding individuals, thereby reducing breeding success. Since the birds are known to have a very small clutch size (≤ 3 eggs) and have very limited time for breeding (April-June), even the slightest negative impact has high potential to reduce breeding success. In the present case, the female bird had a brood patch indicating the ability to breed, but was not seen sitting on a nest or with chicks after attaching the radio-collar. The only advantage in this season was the breeding/territorial calls produced by males, which enabled us to locate and follow the movement of the male to some extent. Playing back the records of male calls has also the potential to attract the birds to traps in this season.

The Western Tragopan seemed to show site fidelity and intensive monitoring of one particular pair enabled us to trap the female bird. Therefore, it is important for future workers to locate areas frequented by the birds before beginning trapping. Combination of both fall-net and leg-hold noose (placing the noose between fall-nets), would be more effective than independent efforts. The traps in particular were highly effective for trapping ground dwelling birds and studies requiring to trap species such as Koklass, Hill Partridge and Eurasian Woodcock may consider these traps. Another important observation to note is that triangulation was preferred over homing-in method. This was primarily because, the bird skulks under a bush/bamboo patch and the proximity of the observer invariably caused the bird to flush downhill, thus introducing bias to actual movement/home range estimate. Since this particular bird was operating in a small area and on smooth slopes, bouncing of radio signal was not a major issue. However, this need not be a general pattern, since Western Tragopan also occupies rugged terrain where the problems related to bouncing of radio signal is greater. In this study, the error polygon ranged from 5 m to 60 m, and was largely within 25 m radius, but this could vary if more birds using diverse topography and different ranging pattern were tracked. Therefore, in mountain terrain, a hybrid

approach involving both triangulation and homing method is likely to be effective. In this hybrid strategy, after locating the bird by triangulation, the accuracy of the locations could be improved by tracking down the bird up to a minimum permissible distance (flushing distance), from where the bird could be located with certainty based on strength of the radio signal, without flushing the bird. In short, we strongly feel that based on our study, future research with adequate number of radio-tagged birds would provide significant contribution to several interesting facets of its ecology and social behaviour, which would translate into long-term conservation plan for this species.

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STUDIES ON HAEMATOZOA OF FAMILY CORVIDAE OF KERALA[1]

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From Family Corvidae, 121 House Crows (*Corvus splendens* Madarasz) and 33 Jungle Crows (*Corvus macrorhynchos* Sykes) from four districts of Kerala state were screened for blood parasites. 78% (94/121) *C. splendens* and 39% (13/33) *C. macrorhynchos* were positive for *Haemoproteus* species. In total, 69.4% (107/154) of the corvids showed haematozoan prevalence. No other species of blood parasite was observed. The parasitic intensity in *C. splendens* was greater (5.2%) than that of *C. macrorhynchos* (3.2%). The haematozoan prevalence observed in the present study has been compared and contrasted with that of the corvids from India, Eastern and Southern Asia, Neotropics, and North America.

Key words: *Corvus splendens*, *Corvus macrorhynchos*, *Haemoproteus*, prevalence

INTRODUCTION

Numerous surveys throughout the world have demonstrated the presence of haematozoa in a wide variety of avian hosts from varying geographical and environmental regions. Avian haematozoa have been implicated in mass mortalities of birds (Herman 1968; Laird and Bennett 1970; Atkinson *et al.* 1986; Bennett *et al.* 1988, 1993; Earle *et al.* 1993; Reppas *et al.* 1995; Simpson *et al.* 1996; Merino *et al.* 2000). To date, about 450 species of haemoparasites have been described from over 4,500 species of birds (Herman *et al.* 1976; Mc Clure *et al.* 1978; Bennett *et al.* 1981, 1982; Threlfall and Bennett 1989; Bishop and Bennett 1992; Evans and Otter 1998; Munoz *et al.* 1999; Mushi *et al.* 1999, 2000; Deviche *et al.* 2001a, b; Adriano and Cordeiro 2001). The better known genera of blood parasites are *Haemoproteus* (140 species from 1,700 bird species of 110 families), *Plasmodium* (54 species from 1,000 species of birds of 97 families), *Leucocytozoon* (96 species from 1,000 species of birds of 98 families) and *Trypanosoma* (90 species from 800 species of birds of 93 families; Threlfall and Bennett 1989).

In India, Nandi (1978) has reported the presence of 96 species of haematozoa of 8 genera, including 51 species of *Haemoproteus*, 11 species of *Plasmodium* and 12 species of *Trypanosoma*. However, Nandi and Bennett (1997) have reported the presence of a total of 111 valid species of haematozoa composed of 64 species of *Haemoproteus*, 28 *Leucocytozoon*, 8 *Plasmodium*, 5 *Trypanosoma* and 6 species of other parasites from the Indian subcontinent. Other works on avian haematozoa in India include those of Acton and Knowles (1914), Bhatia (1938), Chakravarthy and Kar (1945a, b), Ray and Bhatnagar (1953), David and Nair (1955), Narang and Bhatnagar (1969), Sarkar and Ray (1969), Greiner *et al.* (1977), McClure *et al.* (1978), Reddi *et al.* (1980), Pal and Dasgupta (1982), Nandi and Choudhry (1983), Nandi and Mandal (1984, 1985), Nandi *et al.* (1984), Nandi (1985) and Mandal *et al.* (1989). Studies on haematozoans of the birds of Kerala have been scant (Pillai *et al.* 1990; Varghese and Elizabeth 1992).

Of the two species of birds examined from Family Corvidae Common Crow *Corvus splendens* Madarasz is slightly larger than a pigeon, overall black with a dusky grey neck. Jungle Crow *Corvus macrorhynchos* Sykes is larger than House Crow and smaller than a kite in size. This is a glossy, jet-black crow with a heavy bill. These birds are gregarious, omnivorous and are considered to be a commensal of man and an useful scavenger (Ali 1984).

METHODOLOGY

121 *Corvus splendens* were collected from Wayanad, Kozhikode, Kottayam and Pathanamthitta districts and 33 *Corvus macrorhynchos* from Wayanad and Pathanamthitta districts of Kerala, India. A minimum of five blood smears each was prepared from the blood drawn from the brachial vein of the birds. Soon after collection, the smears were air-dried, fixed in 100% methanol, and subsequently stained with Wright's Reagent. Each slide was scanned under 45x and 100x objectives of a calibrated Labo Triumph Research microscope equipped with an ocular micrometer and Yashica F-2 photomicrographic attachment. Positive slides were mounted using DPX. The morphology of the different developmental stages (50 each) of the blood parasites were observed

(e.g. Macro and microgametocytes), and infected and uninfected erythrocytes were studied and measured in micrometers. The parasites were identified according to the descriptions of Greiner and Bennett (1975), Greiner *et al.* (1975), and Bennett and Peirce (1988, 1990). Definitions of prevalence and intensity (per 10,000 erythrocytes) followed are those of Margolis *et al.* (1982).

RESULTS

Of the total of 154 birds examined, 107 (69.5%) were positive for *Haemoproteus* species. This included the 78% (94/121) prevalence in *C. splendens* and 39% (13/33) prevalence in *C. macrorhynchos* (Table 1). No other blood parasites were seen.

In *C. splendens,* in increasing order, prevalence of parasite was 75% (51/68) in Pathanamthitta, 80% (20/25) in Kozhikode, 82% (18/22) in Wayanad, and 83% (5/6) in Kottayam. The intensity of the parasite was 5.2% in Pathanamthitta district. The prevalence was 67% (12/18) in Pathanamthitta proper, 71% (20/28) in Thiruvalla and 86% (19/22) in Kozhencherry.

The macrogametocytes were circumnuclear (14.5 x 3.0 µm) occupying more than 75% of the host erythrocyte. Deep blue, granular and slightly vacuolated cytoplasm showed dark brown granules averaging 17.6 in number. A slight lateral displacement of erythrocyte nucleus was seen. Normal erythrocyte of *Corvus splendens* was 13.1 x 6.3 µm in size and erythrocyte nucleus was 5.1 x 2.5 µm. Infected erythrocyte with macrogametocyte was 13.4 x 5.7 µm and infected erythrocyte nucleus was 5.6 x 2.0 µm. Slight hypertrophy of the erythrocyte and atrophy of its nucleus were noted (Table 2).

The microgametocytes of *C. splendens* were also circumnuclear (11.7 x 3.6 µm) occupying 3/4 of the host cell. Cytoplasm stained light blue with coarse granules. Darkly stained pigment granules were seen clustered at the poles, with an average of 25.4 (in number), which is more than that of the macrogametocyte. The uninfected erythrocyte was 13.1 x 6.3 µm and the erythrocyte nucleus 5.1 x 2.5 µm. The infected erythrocyte was 13.2 x 6.3 µm and the erythrocyte nucleus 5.5 x 1.8 µm (Table 2). A degree of atrophy was noted in the size of the host cell nucleus.

Of the 33 *C. macrorhynchos* examined, 13 (39%) were positive for *Haemoproteus* (Table 1). District-wise the prevalence was 33% (2/6) in Wayanad and 41% (11/27) in Pathanamthitta. Within the district of Pathanamthitta, the increasing order of prevalence was: 0% (0/2) in Adoor, 25% (1/4) in Kozhencherry, 40% (2/5) in Pathanamthitta town and 50% (4/8) each in Thatta and Thiruvalla. The overall parasitic intensity was 3.2%.

The circumnuclear macrogametocyte (16.7 x 2.0 µm) occupied almost 75% of the host cell. Lateral displacement of the host cell nucleus was seen. Cytoplasm stained deep blue with Giemsa stain; it was coarsely granular. Pigment granules were dark brown, with an average of 22.8, scattered

Table 1: Prevalence of haematozoa in corvids

Location	*Corvus macrorhynchos*			*Corvus splendens*		
(District / Place)	TE	TP	PR%	TE	TP	PR%
Wayanad						
Sulthanbathery	6	2	33	22	18	82
Pathanamthitta						
Adoor	2	0	0	0	0	0
Thatta	8	4	50	0	0	0
Pathanamthitta	5	2	40	18	12	67
Kozhencherry	4	1	25	22	19	86
Thiruvalla	8	4	50	28	20	71
Kozhikode						
Kozhikode	0	0	0	25	20	80
Kottayam						
Changanacherry	0	0	0	6	5	83
Total	**33**	**13**	–	**121**	**94**	–

TE = Total number of birds examined; TP = Total number positive for haematozoa; PR% = Percentage of prevalence of haemoparasites

throughout the cytoplasm. In the parasites, pigment granules were seen clumped in two or more regions. Normal RBC of the bird was 12.3 x 6.0 µm, RBC nucleus 5.4 x 2.6 µm. Erythrocyte infected with the macrogametocyte of the parasite was 13.2 x 6.9 µm and nucleus was 5.4 x 2.0 µm (Table 2). Hypertrophy in length and width of the erythrocyte and atrophy in width of the erythrocyte nucleus were seen.

Microgametocytes found in the blood smears were circumnuclear, with coarsely granular cytoplasm staining light blue with Giemsa and measured 16.7 x 3.0 µm. Pigment granules averaged 27 and were clustered at the poles. Erythrocyte infected with microgametocyte was 12.8 x 6.8 µm and infected nucleus 5.0 x 1.5 µm (Table 2). Slight hypertrophy of the host cell and atrophy of the nucleus was seen.

DISCUSSION

In *Corvus splendens*, only one type of *Haemoproteus* – a circumnuclear parasite which occupied more than 75% of the host erythrocyte – was observed. Table 2 compares the general characteristics of the *Haemoproteus* sp. seen in the present study with those of *H. danilewski* and indicates that the former differs from the latter in being smaller, (macro _14.5 x 3.0 µm as opposed to 19.4 x 3.2 µm; micro 11.7 x 3.6 µm as against 17.4 x 3.4 µm), also the macro possesses fewer number of pigment granules 17.6 as against 23.4 (Bishop and Bennett 1990). Whether or not the difference in size and number of pigment granules seen in the *Haemoproteus* species and *H. danilewski* in the present study indicate the existence of a new species of the parasite in *Corvus splendens* of Kerala could not be ascertained until detailed studies are completed.

In *Corvus macrorhynchos* too a single type of *Haemoproteus* sp., which resembled *H. danilewski*, was observed. The size of the macrogametocyte infected RBC in the present study (13.2 x 6.9 µm) was very close to that of *H. danilewski* infected RBC (13.0 x 7.3 µm). Hypertrophy of the host cell was seen in the present study as in *H. danilewski* infection. The size of the microgametocyte infected erythrocyte (12.8 x 6.8 µm) was similar to that of *H. danilewski* infection (12.9 x 7.5 µm; Table 2). The

Table 2: Morphometric parameters of *Haemoproteus* spp. of *Corvus* spp.
(All measurements are in microns)

		Present Study *Corvus splendens*	Present Study *Corvus macrorhynchos*	*H. danilewski**
Uninfected erythrocyte	Length	13.1±0.72	12.3±1.18	12.4±1.1
	Width	6.3±0.95	6.0±1.0	6.8±0.5
Uninfected erythrocyte nucleus	Length	5.1±1.45	5.4±0.77	4.9±0.6
	Width	2.5±0.72	2.6±0.72	1.9±0.3
Infected erythrocyte (Macrogametocyte)	Length	13.4±0.47	13.2±0.95	13.0±0.8
	Width	5.7±0.95	6.9±0.77	7.3±0.5
Infected erythrocyte nucleus	Length	5.6±0.72	5.4±0.77	4.7±0.5
	Width	2.0±0.72	2.0±0.72	2.0±0.2
Macrogametocyte	Length	14.5±1.01	16.7±1.11	19.4±3.4
	Width	3.0±0.71	2.0±0.72	3.2±0.5
No. of pigment granules		17.6±0.84	22.8±0.85	23.4±4.2
Infected erythrocyte (Macrogametocyte)	Length	13.2±0.77	12.8±0.79	12.9±0.8
	Width	6.3±0.63	6.8±0.79	7.5±0.6
Infected erythrocyte nucleus	Length	5.5±0.71	5.0±0.72	4.6±0.5
	Width	1.8±0.68	1.5±0.0	2.0±0.3
Microgametocyte	Length	11.7±1.18	16.7±1.11	17.4±2.3
	Width	3.6±0.77	3.0±0.0	3.4±0.5
No. of pigment granules		25.4±1.58	27.0±1.33	27.6±2.9

*Source : Bishop and Bennett, 1990

Table 3: Prevalence of haematozoa in the avian Family Corvidae

Country/Region	TE	TP	Percent positive for					Source
			H	P	L	T	M	
North America	1970	49.9	25.1	3.4	30.7	10.3	9.6	Greiner *et al.*, 1975
New Jersey and Maryland	323	21.1	13.9	2.5	4.3	0.3	3.1	Williams and Bennett, 1978
Neotropics	67	43.3	17.9	17.9	3.0	1.5	3.0	White *et al.*, 1977
Eastern & Southern Asia	152	26.3	21.7	0.7	4.6	-	2.6	McClure *et al.*, 1978
Indian Subcontinent(1)	616	64.2	4.8	31.3	0.9	0.5	29.7	Nandi and Bennett, 1997
Kerala, India	154	69.5	69.9	-	-	-	-	Present Study

TE = Total number of birds examined; TP = Percentage of total number of birds positive for haematozoa; H = *Haemoproteus*; P = *Plasmodium*; L = *Leucocytozoon*; T = *Trypanosoma;* M = Microfilaria
(1) = Includes India, Pakistan, Bangladesh, Bhutan, Nepal and Sri Lanka

measurements and number of pigment granules of macro- and micro-gametocytes were in accord with those of *H. danilewski*. Table 2 confirms that of the two species of birds the *Haemoproteus* sp. of *Corvus macrorhynchos* resembled *H. danilewski* more than *Corvus splendens*.

The other species identified is *Haemoproteus picae,* which has a halteridial shape with lower number of pigment granules, and the form found in the present study is not in accord with this.

Surprisingly, the overall prevalence of *Haemoproteus* spp. in the *C. macrorhynchos* was only 39% (13/33), which was exactly 50% less than that in *C. splendens* of the two districts from where *C. macrorhynchos* were examined, Wayanad showed a lower prevalence of 33% (2/6) while Pathanamthitta showed slightly higher percentage (40%; 11/27).

The 69.5% (107/154) prevalence of haematozoa recorded from corvids was substantially higher than the 12.5% in corvids of West Bengal (Nandi *et al.* 1984), 21.1% in New Jersey and Maryland (Williams and Bennett 1978), 22.2% in Bharatpur, Rajasthan (Mc Clure *et al.* 1978), 26.3% in Eastern and Southern Asia Mc Clure *et al.* 1978), 33% in Andhra Pradesh (Nandi and Mandal 1984), 40% in Goa (Nandi and Mandal 1985), 43.3% in the Neotropics (White *et al.* 1978) and 49.9% in North America (Greiner *et al.* 1975; Table 3). The prevalence in the present study is closer to the 64.2% in Indian subcontinent (Nandi and Bennett 1997)

In the corvids of North America, Neotropics, and New Jersey and Maryland, the workers reported the presence of *Plasmodium*, *Leucocytozoon*, *Trypanosoma* and *Microfilaria* in addition to *Haemoproteus* (Greiner *et al.* 1975; White *et al.* 1978; Williams and Bennett 1978). The results of the present study differ from those of the above workers in not finding *Plasmodium*, *Leucocytozoon*, and *Trypanosoma*, and are in accord in finding *Haemoproteus*. Studies in the corvids of Indian subcontinent (Nandi and Bennet 1997) showed the presence of *Plasmodium* (31.3%), *Leucocytozoon* (0.9%), and *Trypanosoma* (0.5%), which is at variance with the present study.

Nandi's "Index catalogue of haematozoa from India"(Nandi 1984) has recorded the presence of *Haemoproteus* (de Mello *et al.* (1917), Mc Clure *et al.* (1978) and *Microfilaria* (Sen *et al.* 1965) in *Corvus macrorhynchos*, *Haemoproteus* (Donovan 1904; Bhatia 1978; Mc Clure *et al.* 1978), *Plasmodium* (Donovan 1904; Nandi *et al.* 1984), *Trypanosoma* (Donovan 1904) and *Microfilaria* (Mc Clure *et al.* 1978) in *Corvus splendens*.

The finding of only *Haemoproteus* in *Corvus splendens* is not in accord with that of Mc Clure *et al.* (1978) from Bharatpur, India, where *Microfilaria* was also found, and also differs from that of all other workers listed above who have also found other parasites (Table 3). The results obtained in the present study from *Corvus macrorhynchos* differ from that of Sen *et al.* (1965) in not finding *Microfilaria*. Nevertheless, confirmation that the corvids of Kerala are hosts exclusively of *Haemoproteus* and no other species of haematozoa must await results of further more extensive survey.

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EVALUATING THE STATUS OF FORESTS AND RELATIVE ABUNDANCE OF WILDLIFE: A RAPID SURVEY FROM A REMOTE AND LITTLE EXPLORED TROPICAL EVERGREEN FOREST OF NORTH-EAST INDIA[1]

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This survey was aimed at evaluating methods that could be used to assess the status of forests and the relative abundance of mammals in a remote and little explored tropical evergreen forest of north-east India. The survey was carried out by walking along forest trails for assessing the status of forests and mammals, and through the village surveys to assess the status of wildlife. About 58% of the forests surveyed were under open forest and 27% under partially open cover, indicating the region has more open forest while the closed forest was only 15% The species encounter rate/km was high in an open forest (1.6 (SE=0.22)/km, 0.8 (SE=0.7)/km for a partially open forest and for a closed forest it was 0/km), and the results for the open and partially open forests were not statistically significantly different (Hc=0.39, p=0.73) Out of the 23 mammal species reported for the region, only 26% of the 23 species were encountered during the trail surveys, and only after spending 95% of the total time (56 hours) with the villagers, information on all the species was obtained. The number of species obtained for the survey region complies with the results of other regions that have comparable attributes. When areas with similar affinities are compared, the variance around the mean was only 7%, but in areas that are dissimilar, the variance around the mean was 13%. As compared with the other regions, only 0.37% of the total man-hours were spent to obtain the number of species for the current survey. The village survey appears to be a robust method for a basic or advanced species list, but it may not be an appropriate method to evaluate the forest status.

Key words: trail and village surveys, evaluation, forest canopy and wildlife abundance

INTRODUCTION

Arunachal Pradesh, in the north-east of India, is known for its rich biological and cultural diversity, and has been recognised as one of the 34 biodiversity hotspots of the world (Myers *et al.* 2000). It is also a home to around 26 ethnic human communities with distinctive cultures and rich traditions (Shukla 1965). Unlike the other regions, forests in some areas of Arunachal Pradesh at present do not suffer much from major developmental activities, such as the hydroelectric, irrigation projects and road networks. But the heavy dependency on forests by local communities through shifting cultivation and other livelihood practices is the major conservation concern (Ramakrishnan 1992; Raman *et al.* 1998). The communities are also known for their active involvement in hunting of wildlife for ornamental, medicinal, edible and commercial uses (Aiyadurai and Varma 2003).

There are only a few studies that have been carried out in this region due to the remoteness, ruggedness and incidences of cerebral malaria in the region. High rainfall, frequent landslides, lack of infrastructure facilities and an assumed unfriendly nature of the local communities have also contributed to this. These areas are important for many species of conservation interest and the proposed survey region was particularly reported to have seven species of major large carnivores (Aiyadurai and Varma 2003), three of which (Tiger, Clouded Leopard and Asiatic Black Bear) are categorised in the Vulnerable to Endangered category of the IUCN Red List of threatened species (IUCN 2007), and the remaining four are listed under the Schedule I of the Wildlife (Protection) Act of India 1972 (Menon 2003). The area is also one of the contiguous habitats for the Asian Elephant *Elephas maximus*; conserving these flagship species (Sukumar 1989) or charismatic flagship species (Karanth 1995) or their habitat may eventually protect a considerable amount of biodiversity. However, the Elephant and some carnivore species have become a cause for human-animal conflict, resulting in negative conservation interests. Such problem animals, particularly some carnivore species are being hunted either as a conflict mitigation measure or as a source of food. Under these circumstances the understanding of the status of these species and developing mitigation measures will not only provide knowledge about the species but also receive support from the local communities for their conservation. Secondly, when there is a constraint of time and other resources or manpower, there is a need to identify a robust way of collecting information and this is possible only through adopting all existing methods or through developing new

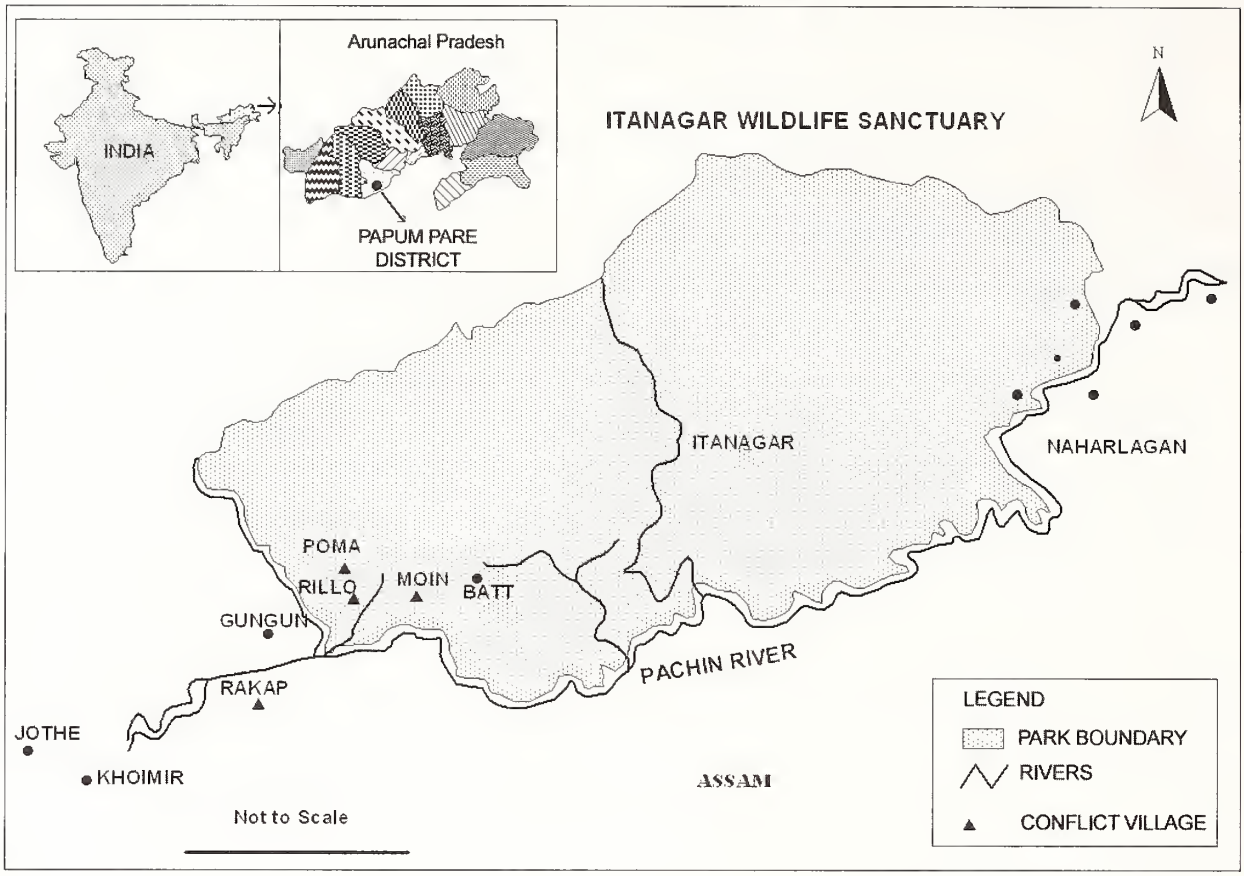

Fig. 1: Map showing Itanagar Wildlife Sanctuary and survey villages in Arunachal Pradesh, north-east India

approaches to data collections (Varman and Sukumar 1995; Varma 2000).

Our initial interest was to evaluate methods that could be followed and eventually be used to assess the status of forests and the relative abundance of wildlife, particularly mammals. Our interest was restricted by the constraints imposed by the landscape features, availability of time and other resources, and non-availability of specific methodologies. However, these limitations did motivate us to identify methods for documentation, compare and review methodologies adopted, and numbers reported from similar landscapes elsewhere. A review and comparison of methodologies adopted provided us with insights into the merits and demerits of each methodology, and comparison of the results with other regions helped us in identifying the accuracy of the knowledge that was gained through this short-term survey.

STUDY AREA

Itanagar Wildlife Sanctuary (Fig. 1), covering an area of 140.30 sq. km, is a part of a contiguous forest cover and one among the notable biodiversity areas of north-east India. The region is mostly hilly (precipitous hillsides are a common feature of this area), and the average altitude of the terrain is 1,000 m above msl. The terrain slopes gently towards south and is highly rugged with mountainous ranges.

The monsoon begins around March-April, and continues till September-October (Anon. 2006). The annual average rainfall is approximately 2,500 mm with June and July as the wettest months. A large number of rivers drain into the area, most of which run from north to south. The landscape is difficult to traverse due to the rugged terrain and dense vegetation. Geologically, the forest area is prone to landslides during summer and is quite unstable.

The forest can be classified mainly as the North Bank Tropical Evergreen (Nahor-Jutuli), Tropical Semi-Evergreen and Secondary forests (Champion and Seth 1968; Kaul and Haridasan 1987). At places, the evergreen and semi-evergreen forests merge with one another and cannot be described separately. The North Bank Tropical Evergreen (Nahor-Jutuli) forests occur at an elevation of 900 m above mean sea level. The tropical semi-evergreen forests occur up to an elevation of 600 m above msl. This type of forest can be further classified into low hills, and plain semi-evergreen and riverine

semi-evergreen forests. Secondary forests occur due to both man-made (mainly shifting cultivation) and natural (mainly landslide or fire) reasons. This type could be further classified into a degraded forest, bamboo forest and grasslands (Kaul and Haridasan 1987)

No survey has been carried out on the status of species not even to generate a species list; however, the region is expected to have a number of mammalian species. Notable among the expected species are Sambar *Cervus unicolor*, Barking Deer *Muntiacus muntjak*, Wild Pig *Sus scrofa*, Indian Elephant *Elephas maximus*, Tiger *Panthera tigris*, Leopard *Panthera pardus*, Clouded Leopard *Neofelis nebulosa*, Jackal *Canis aureus*, Dhole *Cuon alpinus* and small cats. Among the primates, Assamese Macaque *Macaca assamensis*, Rhesus Macaque *Macaca mulatta*, Capped Langur *Trachypithecus pileatus* and Stump-tailed Macaque *Macaca arctoides*.

METHODOLOGY

General

This rapid survey was carried out in March 2003. As an initial approach, a pilot survey was carried out to understand the landscape and socio-economic status, and the information was associated with the status of the forest and wildlife found here. Forest officials were interviewed for specific information on the condition of forests, status of wildlife and information related to the cultural and economic status of the villagers. The survey adopted two approaches in the field.

a) 'Forest trail' survey for assessing the status of the forest and some species of wildlife

b) Village survey for assessing status of some species of wildlife.

Status of Forests

There are well-established forest trails, which are normally used by villagers. Some of these trails were considered for sampling and a total distance of 21 km was surveyed by foot. These trails are located close to villages such as the Rillo, Khoimir and Moin, and were referred as the Rillo, Khoimir and Moin trails. The walks were restricted to the trails as the undergrowth around them was thick and could not be explored. The forests within a 2 km radius from the villages were heavily cultivated (*jhum* cultivation); the forest type within these regions was secondary. After every 20 minutes four nearest trees, type and status of the forest, and observed anthropogenic disturbances were recorded.

Names of the tree species were noted down to associate with the forest types surveyed. The forests were classified into three categories; open, partially open and closed based on the canopy cover. When there was no canopy overhead, it was termed as open; when the canopy of adjacent trees overlapped, with the sky still showing through it was considered as partially open; and when the sky was not visible overhead, it was considered as closed forest (Raman *et al.* 1998; Varma pers. obs.).

Forest Trail Survey

Experienced individuals of the *Nishi* tribe were employed as trackers, and the forest trails were surveyed for animal presence through direct and indirect signs. Before starting the trail survey, information on species that could be encountered was collected from the trackers. This information was later compared with the species encountered during the survey. Trails were walked for direct sightings or indirect evidence such as pellets/scats/hoof marks, feeding and other signs. On sighting an animal sign or on any direct sighting, information on the time of sighting, number of signs (or individuals) and other related information were recorded.

There were a number of constraints as it was not easy to spot and identify footprints and tracks of animals because of the heavy litter on the ground. Care was taken in the identification of scats, as there were chances of encountering domestic dog *Canis familiaris* scats, especially at the periphery the Sanctuary.

Survey through village visit

Information on wildlife and its presence or absence was collected from the villagers. The villagers were able to provide reasonable information that was based on their visits to the forest, time spent, reasons for visiting and other related aspects. It was established that men spend more time in the forest than women, and it was planned to interview two individuals each from three age classes (old and experienced persons, middle aged persons and individuals from the age class in which they start going to forest) from each village. Selecting specific age classes of people was not possible as most of the men were in the forest during the day. People were interviewed randomly as and when they were available. All these approaches were helpful in establishing the socio-economic and cultural profile of the local communities, and its association with the villagers' dependency on the forest and its resources. The knowledge on wildlife species obtained from the villagers helped in developing the questionnaires based on which the interviews were carried out. The time spent on collecting information from each villager and the morphological and behavioural description of each animal by the villagers was noted down. Pictorial guides (Prater 1971; Menon 2003) were very useful for identification, both in the field and while processing data.

Most of the villagers could understand Hindi, and some could also speak English. The young villagers were especially well-versed with Hindi though there were some problems interacting with the older *Nishis*.

Data processing

The data on the occurrence of forest categories was converted into percentages, and the overall, as well as trail-wise, percentage of signs of each category was calculated. The number of signs, relative percentage, mean number of signs, and an overall and mean encounter rate of signs/km were calculated.

Statistica 5.5 (StatSoft Inc. 2001) and PAST (Hammer *et al.* 2001) software packages were used to carry out statistical tests. Non-parametric statistical tests were carried out for the current data set because of the low sample size. To test the relationship between the forest categories and the overall encounter rate for each trail, the expected and observed frequencies of the signs were calculated and this was tested using Chi square test. Shapiro Wilk's W test was used to test the normality of the data, and a Spearman rank correlation test was used for testing the correlation between the encounter rate and canopy cover. The Kruskal-Wallis test was used to test the statistical significance of the number of sightings of each category.

The number of species and their relative frequencies were calculated for the village surveys. The total number of man-hours spent during both trail and village surveys was calculated to develop species-time area curves for both the methods. For comparison of the results with Bago Yoma, Rakhine Yoma, Alaungdaw Kathapa National Park of Myanmar, Mudumalai and Singara Reserved Forests of southern India, the mean number of species, the total number of man-hours spent and the percentage of identifiable species

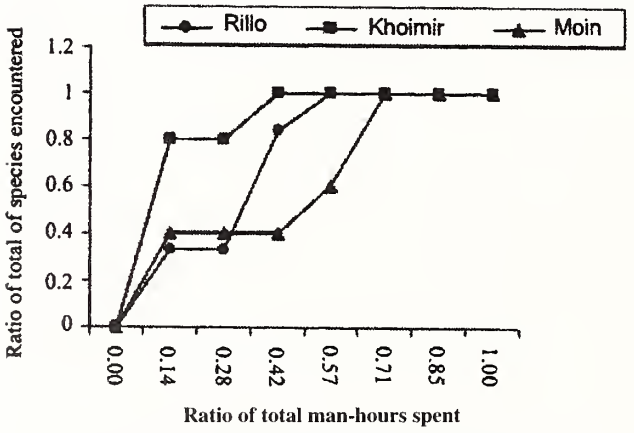

Fig. 2: The species-time curve for the trails close to villages Y-axis: proportion of total number of species whose signs were encountered; X-axis: proportion of total man-hours spent

common to the current survey area for each region were arrived at.

RESULTS

Status of forests

The *Nishi* villages are located in the valley and the adjoining forests were observed to be degraded. The forests were much less disturbed on the other side of the valley. The habitat along the forest trail varied drastically. This variation was found within and across the trails. The microhabitats encountered during the survey were open scrubland, areas under shifting cultivation, bamboo or reed or fern dominated woodlands and riverine habitats. About 58% of the forests surveyed were under open forest and 27% under partially open forest indicating the region has more open forest and only 15% area under closed forest. The status of forests between the covered trails was compared. Rillo trail had no closed forests; Khoimir trail had the highest percentage of open forest (72%), followed by Moin trail (45%).

Encounter rates of wildlife signs

The results show that the encounter rate of wildlife signs/km was highest for Rillo trail (3.50/km) followed by Khoimir (1.26/km) and Moin (1.13/km) trails (Table 1).

Encounter rates of signs in relation to status of forest

The encounter rate/km was high along the trail with less closed forest. The Rillo had only open and partially open forests and more signs were observed in this trail. The Moin, with the least encounter rate/km (1.13) had a high percentage of closed forests. The species encounter rate in relation to the total number of man-hours spent for each trail showed that for the trail close to the Rillo, all the species were encountered in 60% of the time spent. In the Khoimir and Moin trails, 83% of the species were encountered during the survey, and this was achieved through 43% of the man-hours spent in Khoimir trail and after only 85% of the man-hours spent in the Moin trail (Fig. 2).

The mean encounter rate of animal signs for open canopy forest was 1.6 (SE=0.22), for partially open forests it

Table 1: Name of the trails, time spent, distance covered and encounter rate of animal signs/km

S.No	Name of the trail	Time spent rate/km	Distance covered (km)	Encounter (hours)
1	Rillo	6.3	6	3.5
2	Khoimir	8.8	7	1.3
3	Moin	7.5	8	1.1

was 0.8 (SE=0.7) and for closed canopy it was 0, and the difference between the numbers of sightings for open and partially open forests was not statistically significant (Hc=0.39, p=0.73002). Both open and partially open categories were brought under one category of open forest, and the results were tested for the relationship between the openness of the forest cover and encounter rate of animal signs. More animal signs were encountered in open forests, and the difference was statistically significant (χ^2=12.25, df = 2, p<0.0021). Since Shapiro-Wilk's W test for normality suggested that the distribution of encounter rate and canopy cover was not normal (p<0.001), a non-parametric correlation was carried out and it was found that there was no significant correlation between encounter rate and canopy cover (r_s=0.2309, p=0.256, Fig. 3).

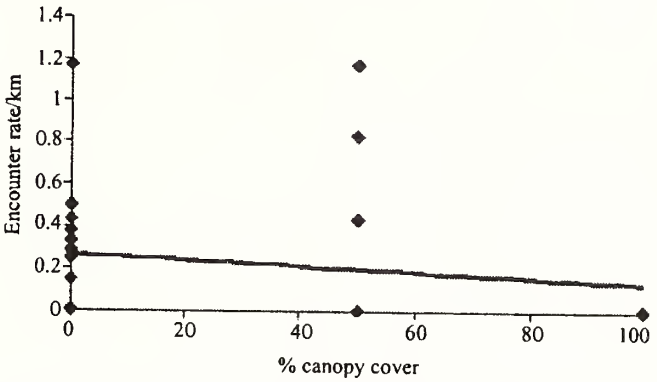

Fig. 3: Canopy cover versus encounter rate
Y-axis: encounter rate/km; X-axis: proportion of canopy cover

Species number reported across the survey methods

The percentage of time spent in collecting information through different approaches showed that 63% of the total time (56 hrs) was spent on village interviews and 37% (33.8 hrs) on trail surveys. With these methods together a total of 23 mammalian species that are key species or easily noticeable were encountered for the region. Out of the 23 species, only 26% (6 species including three unknown species) were encountered in the trail survey. Species detected by the trail survey were, Elephant, Sambar, Barking Deer, Bear (species not known), Canid (Dhole or Jackal) small carnivore (species unknown). The species-time curve for the trail method shows that within 16% of the time spent, all the species (26% of total species) were encountered through this method (Fig. 4) and there were no new species or an increase in the species encounter rate after this time.

Based on the time spent with each villager, a species-time curve was developed for the village interview method, and it was found that there was a gradual increase in the number of species as more and more people were interviewed. Only after spending 95% (54 hrs) of the total time with the villagers, information was obtained on all the species.

Table 2: Number of mammal species reported across different landscapes in Myanmar and India

Region	1	2	3	Altitude (m above msl)	Rainfall (mm)	Terrain	Forest type	Shifting cultivation	Hunting
Itanagar WLS, north-east India	23		0.37	1,000	2,000	Rugged and mountainous	EG, SEG & SF	Yes	Yes
Rakhine Yoma, Myanmar	25	80	33.4	1,200	1,200	Rugged and mountainous	MIXD, SEG & SF	Yes	Yes
Bogo Yoma, Myanmar	22	73	33.4	700	1,600	Rugged and mountainous	MIXD, SEG & SF	Yes	Yes
AKNP, Myanmar	20	80	5.58	1,000	1,500	Rugged and mountainous	MIXD, SEG & SF	Yes	Yes
Mudumalai WLS & Singara Reserved Forest, southern India	36	80	27.1	1,000	1,500	Undulating	DD, MD & SC	No	No

						Number of species reported	
	1	2	3	Altitude (m above msl)	Rainfall (mm)	Regions only of Myanmar	Myanmar & Itanagar WLS
Mean	25	78	24	980	1,560	22.3	22.5
SE	3	2	11	89	144	1.4	1
CV %	12	2	47	9	9	6.5	4.44

1 - No. of species encountered; 2 - Percentage of identified species shared with Itanagar WLS; 3 - Percentage of total man hours spent for all the regions;
EG - evergreen; SEG - semi evergreen; SF - secondary forest; MIXD - mixed deciduous; DD - dry deciduous; MD - moist deciduous; SC - scrub forest

It appears that more than 50 man-hours are needed with villagers to get information on all the species encountered and to reach the asymptote in the species-time curve (Fig. 4).

Species number reported across different landscapes

The survey was short-term (a total of 3 weeks, spread across 89.8 hours in March) in nature due to several constrains in data collection; a comparison of the number of mammalian species reported across similar habitats elsewhere was attempted. This was done to estimate an expected number of species that could be a key species or easy to locate or species of conservation interest for the survey area. A comparison of species recorded in some regions of Myanmar was made. Some regions in Myanmar have similar landscape features (altitude and terrain) and some similar wildlife species, along with a low density of human groups. They are also reported to have similar cultural or traditional affinities, food and other resource gathering approaches involving shifting cultivation, hunting of wildlife and a dependency on forest products (Table 2). The regions selected for this comparison were Bogo Yoma (central Myanmar), Rakhine Yoma (western Myanmar) and Alaungdaw Kathapa National Park (AKNP - north Myanmar). The number of mammalian species reported for these regions were 25, 22 and 20 respectively (Varma pers. obs.; Aiyadurai and Varma 2003) translating to an average of 22.3 species (95% CI=18.8 to 25.8) If the current survey results of 23 species was included and the mean number of species was calculated for all these regions, a mean of 22.5 species (95% CI=20.1 to 24.8) would be the result for all these regions. Based on this, an expected number of 24 to 25 species (this assumption is based on the 95% CI of the average number of the species of all these regions) could be computed for the survey area, and the current survey estimated a number of 23 species. If the species number reported for large mammals in mixed deciduous habitat in southern India is also included (Sivaganesan and Desai pers. obs.; Varma pers. obs.), an average of 25.2 mammals (95% CI=19.0 to 31.4) can be estimated.

A comparison across evergreen (south-east Asia) and mixed deciduous (southern India) forests showed that the expected number of species of mammals for the survey area could be 19 to 31. However, when areas with similar affinities are compared, the variance around the mean is narrow (only 7%), but in areas that are dissimilar, and are known to share some percentage of similar species, the variance around the mean is relatively high (13%). The other interesting finding of this comparison is that the relative proportion of the man-hour spent for arriving at these numbers for all these regions varied (mean 24%, SE=11.3, CV=47%) and only 0.37% of man-hours were spent to encounter all the species for the current survey region.

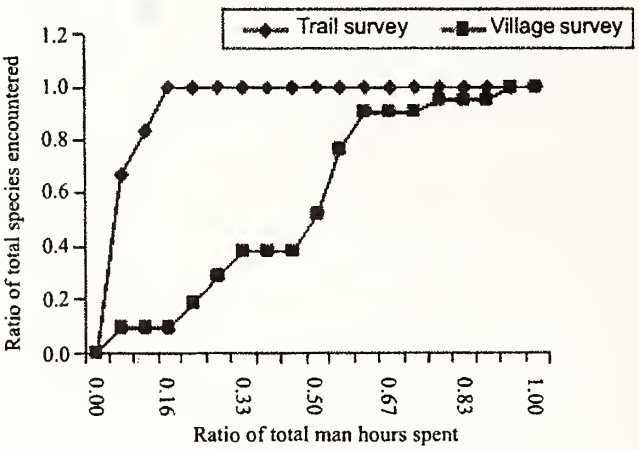

Fig. 4: The species-time curve for the survey methods The proportion of the total number of species encountered is plotted against the proportion of total man-hours spent

Status of species encountered through trail and village survey

No mammalian species was sighted along the trails. However, several signs of animal presence were recorded. These signs could be attributed to seven species or classified into five broad categories such as canids (Dhole and Jackal), cervids (Barking Deer and Sambar), small carnivores (Jungle and other cats), Bear (Himalayan Black Bear) and Elephant. Among them, mean signs of canids dominated followed by elephants, cervids, small carnivores and bear. However, the differences between numbers of signs of all these categories were not statistically significant (Hc=7.44, p=0.140).

Number of species recorded by village survey

Based on the reasons for *Nishis* to visit the forest, time spent, forest products used by the community and the animals that visited human habitations, the presence of 23 species of mammals could be reported for the region, out of which 65% of them were readily identifiable (Table 3). The very important aspect of the results is that the region has seven species of predators (Table 2), of which three (43%) are included in the Vulnerable (facing high risk of extinction) category and one (14%) is within the Endangered (facing very high risk of extinction) category of the IUCN Red List of threatened species. Five out of the seven species are under the Wildlife (Protection) Act of India's Schedule I category, which affords a high level of protection. Including the Asian Elephant, the region has six species of large herbivore mammals.

Out of the 23 species reported by the villagers, they were able to provide information on the frequency of sightings for 20 species (87%), and this indicated that the Barking Deer, Elephant, Jackal, Wild Boar, Capped Langur, Himalayan Black Bear and Dhole were the more commonly found

Table 3: List of mammals reported for the region by the villagers

Species	Scientific Name	Remarks
Leopard	*Panthera pardus*	
Tiger	*Panthera tigris*	
Clouded Leopard	*Neofelis nebulosa*	
Jungle Cat	*Felis chaus*	
Dhole	*Cuon alpinus*	
Jackal	*Canis aureus*	
Mongoose	*Herpestes* spp.	
Himalayan Black Bear	*Selenarctos thibetanus*	
Capped Langur	*Trachypithecus pileatus*	
Elephant	*Elephas maximus*	
Barking Deer	*Muntiacus muntjak*	
Sambar	*Cervus unicolor*	
Gaur	*Bos gaurus gaurus*	
Indian Porcupine	*Hystrix indica*	
Wild Goat		Species not known
Wild Boar	*Sus scrofa*	
Soku*		A small canopy dwelling animal
Taas*		A small canopy dwelling animal
Sukung*		A small canopy dwelling animal
Aama kochchi*		A Squirrel-like brown coloured small animal
Sekke*		A canopy dwelling animal (brown-black in colour, long tail)
Tahi*		A canopy dwelling animal with long tail
Juamola*		A small cat

* - *Nishi* names and the animals described by the local people and their English names could not be identified

species. Rarely seen species included the Sambar, Gaur, Wild Goat, Jungle Cat and Tiger. The elders from the villages also felt that species such as the Sambar, Gaur and Wild Boar used to be sighted more frequently and found in larger numbers, but their frequency of sighting and numbers have been considerably reduced. Another interesting result of the village survey is that, due to Barking Deer's localized distribution, same animals have been encountered frequently giving the impression that there are more Barking Deer in the region.

DISCUSSION

The current survey area in the Itanagar Wildlife Sanctuary and adjoining regions of Arunachal Pradesh was dominated by an open forest indicating large-scale destruction to the forest cover in this region. Studies in north-east India and Laos show that excessive agricultural activity through shifting cultivation not only decreased the forest cover, but also changed the forest into an open secondary woodland shrub (Timminus and Evens 1996; Raman *et al.* 1998). Surveys carried out on large mammals in eastern Cambodia and north-east India identified the practice of shifting cultivation as one of the threats to wildlife habitats (Desai 1996; Hillaludin *et al.* 2005; Mishra *et al.* 2006; Datta *et al.* 2008). On the other hand, in the recent survey, the patterns of high encounter rates of species in less closed trails and the species-time curves for all the trails could support the assumption that open forests attract more large mammals. It could be argued that a greater number of sightings of animal signs in open canopy areas may not have any ecological significance, but could be due to a relatively high visibility of the open canopy sites. However, a closer examination may suggest that the results of encounter rates of animal signs/km may not be related to the percentage of openness of each trail but may be due to the openness (or secondary forests with poor canopy cover) permitting more undergrowth and providing greater forage or forage space availability for herbivores. The region primarily had closed canopy evergreen forests (Kaul and Haridasan 1987), but shifting cultivation practices followed by the local communities had created more secondary forests and may become ideal sites for many species of mammals.

The number of species encountered through the trail survey was very low, and this could reflect the low density of wildlife species. The species (26% (N=6) of the total number) encountered during the trail survey were within 16% of the total and this pattern suggests that more attempts are needed to encounter the remaining 74% of the species. There were a number of constraints in using trail survey methods, as footprints and tracks of animals were not easy to spot or identify because of the heavy litter on the ground. Including livestock, only six categories of animal signs were encountered during the trail survey, of which only the Asian Elephant was possibly identifiable from the signs. Examples of low density or encounter rate of animal signs has been observed in other regions of Southeast Asia and a number of reasons could be speculated on this. Duckworth (1996) attributed these to the shy nature of the species, hunting pressure and fires set by the villagers. However, the relative frequencies of signs and encounter rates do have the advantage of predicting the status of prey and predators in a situation where prey numbers are falling due to heavy hunting and predators are known to prey on domestic animals. Apart from this, trail surveys could be useful for collecting systematic data on the status of forests. In the village interview method, 60% of the time was spent in obtaining the information. As experienced by Duckworth (1996), in Vietnam, villagers gave

convincing reports of several key species of mammals through village surveys, providing vital information of expected species in the survey area. The information on wildlife species was based on the vast and accumulated experience and knowledge of villagers. This survey also illustrated that not only the number of people but also the time spent with each person is a very important factor for obtaining a reasonable level of information about a species. If enough time is not spent, it is likely that different people could refer to a single species as two different ones or two different species could be considered as one. Yet, it is important to know the optimal period one has to spend with a given person for the investigation. Overall, the village survey appears to be a robust method for a basic or advance species list, but it may not be an appropriate method to evaluate the forest status.

Comparison of results from other regions indicates that the survey results match with the expected number of species for regions that have similar settings. Conversely, when observations were compared with the regions with less or no similar affinities, there was a variance in the results. However, these surveys (areas that were compared) resulted in knowing only key species or species that were easy to spot and gave no guarantee for others that are lesser known. It is important to note that there is a difference between the numbers of mammalian species found in a given region and the expected number of species that could be encountered through surveys or the experience of exploring forests. Although the survey was aimed at assessing the status of wildlife, in particular mammals, there was no scope for understanding the status of rodents, bats, elusive lesser-known species and other mammalian species that are not known to Science. Francis *et al.* (1996) reports that bats and small mammals represent a high proportion of the mammalian diversity; however, even to develop a basic checklist of these groups, a great deal of involvement and expertise are needed. Given these constraints we assume that understanding the status of flagship species and conservation of their habitat will eventually help in understanding the status of lesser known, but highly diverse mammalian species. In Nam Phu National biodiversity area of Lao PDR, after 300 man-days of survey, 46 species of non-volant terrestrial mammals were reported (Venkatraman pers. comm.), and Duckworth (1996) reported 30 species for the training and model forest of the Vientiane Forestry College in Laos. Desai (1996) reported 44 species of mammals for Monddulkiri and Rattanakiri provinces of eastern Cambodia, and there was no assurance that all the mammalian species of these regions were found through the surveys. The other important factors are the total area and number of mammalian species reported for a region. Sivaganesan and Desai (pers. obs.) reported 33 species for a 120 sq. km forest and only 31 species for 321 sq. km in southern India. This could indicate that there may be a relationship between the number of species and the quality of the area or microhabitat found in a given area, and the species number may not be related to the size of the area. Apart from these uncertainties, surveys need a lot of time, resources and expertise for all the species present to be encountered in a region.

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DICLOFENAC LEVELS IN LIVESTOCK CARCASSES IN INDIA BEFORE THE 2006 "BAN"[1]

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Three species of *Gyps* vulture, once common across the Indian subcontinent, have declined by more than 97% in India since 1992, and are now on the verge of global extinction. The decline is due to contamination of their food with diclofenac, a non-steroidal anti-inflammatory drug (NSAID) commonly used as a painkiller for livestock in India. On May 11, 2006, the Drug Controller General (India) ordered the withdrawal of all licences granted for the manufacture of diclofenac for veterinary use in India within three months. To monitor the effectiveness of this ban in protecting *Gyps* vultures it is vital to verify levels of diclofenac in livestock carcasses in India both before and after the ban, to determine whether diclofenac use is being reduced. In this study, we collected liver tissue samples from 1,848 livestock carcasses at 63 carcass dumps and four slaughterhouses across 12 Indian states during the period May 2004 to June 2005. The diclofenac levels were quantified using liquid chromatography-electrospray ionization mass spectrometry, with a limit of quantification (LOQ) of 10 µg/kg and limit of detection (LOD) of 4 µg/kg. Across the 12 states, diclofenac residues were found in 10.1% of livestock carcasses sampled: a prevalence of contamination more than sufficient to cause widespread mortality of vultures. There were significant differences in the prevalence of diclofenac between states and sites, and between the species and age-classes of animals, with cattle having a higher prevalence of diclofenac than any other species, and with higher levels of contamination in female animals. In addition, our sampling revealed differences in the daily intake rate of carcasses between sites, with an overall average of 7.47 ±0.58 animals per day across the 63 carcass dumps, and a maximum of >50 animals per day at Ludhiana (Punjab). Despite the large number of carcasses available, *Gyps* vultures were only sighted for three days out of the total 169 days of survey time spent at carcass dumps. The large number of carcasses and low numbers of vultures demonstrate that food availability is not an important factor affecting vulture populations in India. Repeated surveys, following the methods detailed in this study, are now vital to monitor and assess the impact of diclofenac levels in livestock carcasses available to vultures.

Key words: Diclofenac, livestock carcasses, conservation, *Gyps* vultures, India

INTRODUCTION

Veterinary use of the non-steroidal anti-inflammatory drug (NSAID) diclofenac is the main cause of the catastrophic decline in populations of three *Gyps* species of vulture, *Gyps bengalensis* (Oriental White-backed vulture), *Gyps indicus* (Long-billed vulture) and *Gyps tenuirostris* (Slender-billed vulture) endemic to South Asia (Green *et al.* 2004, 2006; Oaks *et al.* 2004; Shultz *et al.* 2004). Their populations in India have declined by more than 97% since 1992 (Prakash *et al.* 2003; Green *et al.* 2004), with numbers of Oriental White-backed vultures decreasing by more than 99.9% from 1992 to 2007 (Prakash *et al.* 2007). These population declines have left all three species of vulture at a high risk of global extinction and led to them being listed as Critically Endangered by the IUCN (World Conservation Union) (IUCN 2007). Population declines continue at rates of 16% to 44% per year (Green *et al.* 2004; Prakash *et al.* 2007).

Diclofenac is a widely available NSAID across the Indian subcontinent, where it is used as an antipyretic, anti-inflammatory and/or analgesic for livestock treatment. Vultures are exposed to the drug when they consume carcasses of livestock that were treated with diclofenac shortly before death. *Gyps* given therapeutic doses of diclofenac, or fed diclofenac-contaminated tissue, die within days from kidney failure with clinical signs of extensive visceral gout (the formation of uric acid crystals on/within tissue) (Oaks *et al.* 2004; Swan *et al.* 2006).

Modelling has shown that the observed rate of population decline could be caused by contamination of a very small proportion (0.13% to 0.75%) of ungulate carcasses available to vultures with a lethal level of diclofenac (Green *et al.* 2004). Until recently there have been no data available

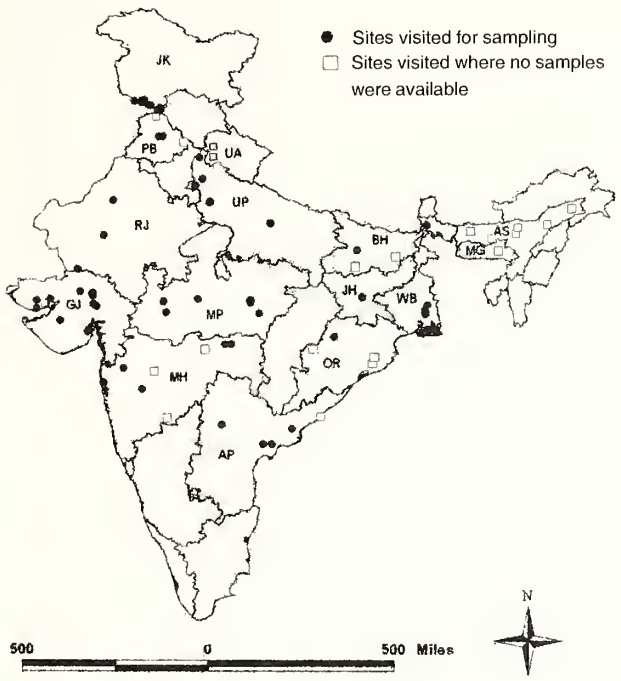

Fig. 1: Sites visited for sampling

on the residue levels and prevalence of diclofenac in ungulate carcasses available to vultures across India. Following the publication of a very small data set (Taggart *et al.* 2007a), Taggart *et al.* (2007b) further reported on the analysis of 1,848 liver samples collected from livestock carcasses from 12 states in India. This analysis revealed that the overall prevalence of detectable diclofenac (>10 µg/kg) across all states was 10.1% and varied significantly between states, with up to 22.3% prevalence determined in the state of Bihar.

On May 11, 2006, the Drug Controller General (India) ordered the withdrawal of all licences granted for the manufacture of diclofenac for veterinary use in India within 3 months of this date (Kumar 2006). Though this was a very positive and significant step in terms of acting to halt the rapid decline of *Gyps* vultures in India, it may in reality take considerable time and effort to effectively remove all existing stocks of veterinary formulations of the drug and to prevent the use of the drug derived from other sources (Taggart *et al.* 2007b). Before the ban, diclofenac was probably one of the most (if not the most) commonly administered and cheapest NSAIDs used in veterinary medicine in India. Industry sources estimate that some 10 million domesticated animals are treated annually with diclofenac (MoEF 2006). Therefore, substantial stocks probably still exist, and demand is likely to continue at a high level.

If *Gyps* vultures are to survive in India, the Indian veterinary market should be strictly monitored to ensure the complete removal of diclofenac. The collection of liver tissue samples from livestock carcasses, available countrywide, and their analysis for the detection of diclofenac residues is a reliable technique to test whether or not this drug is being used for veterinary treatment in India. Therefore, relevant pre-ban data is required to assess the effectiveness of the ban in the future. Taggart *et al.* (2007b) published data on overall and state-wide residual concentration levels and the prevalence of diclofenac; however, site-specific details were beyond the scope of that report and remain unspecified. Such data is of critical importance for assessing the effectiveness of the ban at local and regional scales. Here, we present site-specific data using the 1,848 liver samples utilised by Taggart *et al.* (2007b) and examine variations in the data by sites within states. We also note differences between livestock species, sex, type of death, category of collection site and age.

METHODS

Field Sampling of Livers from Domestic Ungulate Carcasses

Liver samples from cattle (n_t = 893), buffalo (n_t = 861), sheep (n_t = 48), goat (n_t = 39), horse (n_t = 6) and camel (n_t = 1) were collected from 67 sites in 12 states of India (Fig. 1) between May 2004 and July 2005. The states from which samples were collected were Andhra Pradesh (AP, n_t = 161), Bihar (BH, n_t = 121), Gujarat (GJ, n_t = 65), Jammu and Kashmir (JK, n_t = 77), Jharkhand (JH, n_t = 54), Madhya Pradesh (MP, n_t = 195), Maharashtra (MH, n_t = 194), Orissa (OR, n_t = 52), Punjab (PB, n_t = 76), Rajasthan (RJ, n_t = 310), Uttar Pradesh (UP, n_t = 449) and West Bengal (WB, n_t = 94). Three more states, Assam (AS), Meghalaya (MG) and Uttarakhand (UA), were also visited (for 20 days in all), but samples could not be collected because sites in these states were either not receiving any livestock carcasses at the time that we visited, or, we could not obtain permission to take samples from the carcasses, or, carcasses were not being skinned and left for scavengers because local authorities had switched to carcass burial as a disposal method.

Samples were collected from carcasses at Municipal Corporation Carcass Dumps (MCCD, n_t = 1,068), Co-operative Carcass Dumps (CCD, n_t = 28), Animal Charity Carcass Dumps (ACCD, n_t = 32), Private Carcass Dumps (PCD, n_t = 448) and Slaughterhouses (SH, n_t = 272). MCCDs are managed by the municipalities of certain cities to dump/process carcasses, whereas CCDs are owned by co-operative societies involved in the business of carcass processing (for leather and bone). PCDs are owned by independent skinners

or small contractors, while ACCDs are owned by animal charities. Slaughterhouses were included in the survey because a substantial amount of waste (the offal) is disposed of on-site and is available to vultures. The sites visited were simply those encountered during fieldwork visits for which it was possible to obtain access and permission to gather samples. Consequently, they were not necessarily a representative sample of all locations at which livestock carcasses were available to vultures across India, however; we did not consciously select sites based on any criteria that were likely to lead to an atypical prevalence of diclofenac-treated animals.

For every dead animal that arrived at the site, the liver was initially removed from the carcass by local skinners working at these sites; we then removed three tissue subsamples of 3-4 gm each from three different regions of the whole liver using a surgical scalpel. These three subsamples were then bulked together into one watertight 25 ml polypropylene sample container, and further sealed with a tape and individually labelled. The scalpel, gloves and a marble cutting stone (upon which subsamples were excised from the bulk liver) were thoroughly cleaned after sampling each liver to reduce the risk of cross-contamination. Batches of ten samples were then placed into labelled ziplock bags and stored on ice in a portable refrigerator. Subsequently, all samples were transferred to a freezer and stored at -20 °C until extraction.

At all sites, except Ludhiana in the state of Punjab, every carcass that arrived during our visit was sampled, regardless of species, age or condition. There is therefore no bias with respect to the species, age or condition of the dead animals sampled at 66 of the 67 sites visited. At Ludhiana, >50 carcasses arrived at the site each day and it was not possible to sample every carcass. Samples at this site ($n_t = 61$) were taken predominantly from young prime adults and mature adults. We stayed at sampling sites during the day time to record the total number of carcasses arriving there and spent an average of 3.4 days (range 1-21 days) at each of the 63 carcass dumps and 3.3 days (range 1-4 days) at each of the slaughterhouses.

Diclofenac Extraction and Measurement

Full details of the extraction and measurement techniques used can be found in Taggart *et al.* (2007b). However, briefly, diclofenac was extracted from 0.5 gm of liver tissue using 2 ml of HPLC grade acetonitrile, and an Ultra Turrax IKA T8 hand held homogeniser. Mixtures were centrifuged at 1,000 g for 5 minutes, the supernatant filtered and then stored in crimp-top LC vials at -20 °C until analysis. Diclofenac levels were determined by liquid chromatography-electrospray ionisation mass spectrometry (LC-ESI/MS) using an Agilent 1100 series instrument (1946D). The instrument was calibrated using standards ranging from 5 to 1,000 µg/kg in diclofenac concentration, generated using diclofenac sodium salt (Sigma-Aldrich, D6899). The limit of quantification (LOQ) for this technique (back calculated to wet tissue concentration) was found to be 10 µg/kg, and the limit of detection (LOD) was 4 µg/kg.

Statistics

We used chi-square tests to compare the diclofenac prevalence levels between sites within each state, and restricted this analysis to sites where >6 livestock carcasses were sampled. Chi-square tests between two groups utilised the Yates correction for continuity. Tests of variation among sites in daily carcass intake rates were made using one-way ANOVA analysis. All statistical tests were two-tailed with significance set at $p < 0.05$. Because of the large number of comparisons (for each state; between sites, site type, age, gender and species) we did not perform post-hoc tests after the initial chi-squared test or ANOVA, but we report if there were differences between groups and present either the mean value (if there is no difference) or the highest intake rates or prevalence rate if there were significant differences. The individual prevalence and intake rates are presented for each site and state in Tables 1 and 2. A detailed statistical analysis of the influence of gender, species, dump-type and age for the nationwide results is presented in Taggart *et al.* (2007b).

RESULTS

A total of 1,848 samples were collected from 67 sites across India, of which 63 sites were carcass dumps processing animals that died naturally, and four were slaughterhouses. Overall, the percentage of livestock carcasses found positive for diclofenac was 10.1% (n_t = 1,848). There was no significant difference in diclofenac prevalence for animals collected in urban areas as opposed to rural areas (urban diclofenac prevalence (d_p) = 10.3% (n_t = 1,718); rural d_p = 6.9% (n_t = 130); $\chi^2_1 = 1.06$, $p = 0.30$). Excluding slaughterhouses, carcass arrival rate varied significantly between sites (one-way ANOVA $F_{62, 148} = 12.864$, $p < 0.001$), ranging from 40.8 ±6.3 to 0.3 ±0.3 carcasses per day, with an overall average of 7.5 ±0.6 (n_d = 211). Arrival rates also varied significantly between site type ($F_{66, 157} = 9.978$, $p < 0.001$), with average rates varying in the order SH (20.9 ±4.5) > MCCD (14.6 ±1.2) > ACCD (5.3 ±2.5) > PCD (3.6 ±0.3) > CCD (3.5 ±0.8).

Tables 1 and 2 show the breakdown of carcass intake by site within each state, as well as name of the site, type and geographical coordinates to enable repeated surveys to be undertaken in the future. As none of the samples collected in Orissa were positive for diclofenac (all samples were taken at a slaughterhouse), this state is not considered further in comparative analysis of prevalence by species, gender, death type, dump type and age group.

In Andhra Pradesh, two of four sites sampled were positive for diclofenac, and d_p varied significantly between these two sites ($\chi^2_1 = 6.00, p < 0.05$; 2.6% at Hyderabad and 28.6% in Gudiwada). There was no significant difference in the arrival rate of dead animals between these sites ($F_{3,14} = 2.917, p = 0.071$) with an overall average of 8.9 ±1.4 animals per day for the state. By species, diclofenac was detected in buffalo, cattle and horse carcasses, and the d_p varied significantly between them (Table 2). The d_p was not significantly different between the genders, age groups or the site types.

In Bihar, Patna was the only site sampled, which received an average of 5.8 ±0.5 carcasses per day, the d_p was 22.3%, and differed significantly by gender and age, but not by species.

In Gujarat, of 12 sites sampled, five were positive for diclofenac, but the d_p was not significantly different amongst them ($\chi^2_4 = 3.94, p = 0.41$). There were significant differences among sites in the arrival rate of carcasses ($F_{11,6} = 14.911$, $p = 0.002$), with the highest numbers arriving at the Dabala Panjarapole site, and an overall mean of 3.6 ±1 carcasses per day for the state (Table 1). Diclofenac was recorded in cattle and buffalo, with no significant differences noted in d_p by species, gender or site type, but, there were differences with age.

In Jammu and Kashmir, of eight sites sampled only two were positive for diclofenac, and the d_p was not significantly different between them ($\chi^2_1 = 0.20, p = 0.66$). There was no significant difference among sites in the arrival rate of carcasses ($F_{7,16} = 1.193, p = 0.361$), with an overall average of 3.4 ±0.6 for the state. The R.S. Pura site received the maximum number of carcasses per day, but was not significantly different in this respect to the other sites. By species, diclofenac was found in cattle and buffalo, but the d_p was not significantly different between these, and it did not differ by gender or age.

In Jharkhand, two sites were sampled, one of which, the Kantatoli slaughterhouse site, was positive for diclofenac. Samples collected at the Harmu Road site were all from animals that died naturally but none were positive for diclofenac. However, this site only received an average of 1.5 ±0.5 carcasses per day, so only three animals were sampled. Diclofenac was found in cattle and buffalo, and there were no significant differences in d_p by species, gender, site type or age.

In Madhya Pradesh, of the eight sites sampled five were positive for diclofenac, but the d_p did not differ significantly between them ($\chi^2_4 = 4.48, p = 0.35$). There was a significant difference in daily arrival rate among sites ($F_{7,19} = 7.682, p < 0.001$), with the highest number arriving at Bhopal (15 ±2.7). The d_p differed significantly by gender and age, but not by species or site.

In Maharashtra, of eight sites sampled only two were positive for diclofenac, and the d_p did not vary significantly between them ($\chi^2_1 = 2.81, p = 0.09$). There was a significant difference among sites in daily arrival rate ($F_{7,10} = 13.696$, $p < 0.001$), which was highest at the Mumbai site (40.8 ±6.3). The d_p varied significantly by age but not by gender, species or site type.

In Punjab, of the seven sites sampled three were positive for diclofenac, but the d_p did not vary significantly between them ($\chi^2_2 = 0.30, p = 0.86$). There was a significant difference among sites in daily carcass arrival rate ($F_{6,8} = 6.349, p = 0.010$), with the highest rate occurring at Ludhiana (15.3 ±3.1 animals sampled per day, with >50 arriving each day). The d_p did not differ significantly by species, gender, site type or age.

In Rajasthan, of the three sites sampled two were positive for diclofenac, but the d_p did not vary significantly between them ($\chi^2_1 = 2.93, p = 0.09$). The arrival rate was highest in Jodhpur (22.7 ±2.4) and was significantly different to the other two sites visited ($F_{2,15} = 18.52, p < 0.001$). The d_p varied significantly by age, but not by gender, species or site type.

In Uttar Pradesh, eight out of nine sites sampled were positive for diclofenac, and the d_p varied significantly among them ($\chi^2_7 = 26.01, p < 0.001$). There was a significant difference in the daily arrival rate at sites taking animals that died naturally ($F_{6,24} = 23.89, p < 0.001$), with the highest rates at Ghaziabad (19.7 ±1.7 carcasses per day). The d_p varied significantly by species, gender and site type, and among age groups.

In West Bengal, two of the four sites sampled were positive for diclofenac, but the d_p did not vary significantly between them ($\chi^2_1 = 0.45, p = 0.50$). There was no significant difference among sites in daily arrival rates ($F_{3,16} = 2.939, p = 0.065$), with an overall average of 4.7 ±0.7 for the state. The d_p varied significantly by age but not by gender, species or site type (Table 2).

Table 1: Prevalence and concentration of diclofenac in liver samples from domestic ungulate carcasses sampled in 12 states of India

State (sampling date)	Site name	Geographic location (GPS reading) (decimal degrees)	Rural (R) / Urban (U)	Dump type	Sampling days (n_d)	Daily carcass Arrival rate	Samples collected (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentration µg/kg
Andhra Pradesh										
(12.04.05 to 26.04.05)	Gandepalli	N 17.1366 & E 81.9645	R	PCD	1	2	2	0	n/a	n/a
	Gudiwada	**N 16.4301 & E 80.9977**	**R**	**PCD**	**2**	**3.5**	**7**	**28.6**	**229**	**195 - 269**
	Hyderabad	N 17.3508 & E 78.5823	U	MCD	14	10.8	151	2.6	44.5	24 - 80
	Vijaywada	N 16.4270 & E 80.5727	U	PCD	1	1	1	0	n/a	n/a
Bihar										
(25.05.05 to 14.06.05)	**Patna**	**N 25.5817 & E 85.1152**	**U**	**PCD**	**21**	**5.8**	**121**	**22.3**	**258.8**	**15 - 3,582**
Gujarat										
(25.05.04 to 06.06.04)	Ahmedabad	N 22.9760 & E 72.5620	U	MCCD	4	2.3	9	0	n/a	n/a
	Bhachau	N 23.3283 & E 70.3469	R	MCCD	1	10	10	10	1,150	1,150
	Bhavnagar	N 21.7813 & E 72.1327	U	MCCD	2	2.5	5	0	n/a	n/a
	Bhuj	N 23.2655 & E 69.6960	U	MCCD	2	2	4	25	1,695	1,695
	Dabala panjarapole	N 23.0937 & E 72.4114	R	ACCD	1	16	16	0	n/a	n/a
	Linch panjarapole	N 23.4951 & E 72.3846	R	ACCD	1	1	1	0	n/a	n/a
	Mahesana panjarapole	N 23.6106 & E 72.3694	U	ACCD	2	2.5	5	0	n/a	n/a
	Nagalpur	N 23.5790 & E 72.3606	R	PCD	2	1	2	50	743	743
	Paragpur panjarapole	N 22.8910 & E 69.6905	R	ACCD	1	1	1	100	1,186	1,186
	Rajkot	N 22.3313 & E 70.8639	U	MCCD	1	2	2	0	n/a	n/a
	Rajkot panjarapole	**(N 22.3114 & E 70.8131)**	**U**	**ACCD**	**1**	**9**	**9**	**22.2**	**523.2**	**86 - 3,183**
	Roadside (Mehsana - Bhuj)	N 23.7059 & E 71.7930	R	PCD	1	1	1	0	n/a	n/a
Jammu & Kashmir										
(20.01.05 to 04.02.05)	Gandhinagar	N 32.7180 & E 74.8543	U	PCD	8	4.8	38	5.3	26.5	16 - 44
	Karan Baug	**N 32.6725 & E 74.8314**	**U**	**PCD**	**5**	**3**	**15**	**6.7**	**100**	**100**
	Kujwani	N 32.6705 & E 74.3767	U	PCD	3	1.3	4	0	n/a	n/a
	Miran shahib	N 32.6322 & E 74.8030	R	PCD	1	2	2	0	n/a	n/a
	R. S. Pura	N 32.6228 & E 74.7093	U	PCD	1	6	6	0	n/a	n/a
	Sambha	N 32.4640 & E 75.1732	U	PCD	1	1	1	0	n/a	n/a
	Sohanjan village	N 32.6915 & E 74.7334	R	PCD	3	3.3	10	0	n/a	n/a
	Vijaypur	N 32.5054 & E 75.0731	R	PCD	1	1	1	0	n/a	n/a
Jharkhand										
(07.06.05 to 10.06.05)	Harmu Road (Ranchi)	(N 23.3632 & E 85.3491)	U	PCD	2	1.5	3	0	n/a	n/a
	Kantatoli (Ranchi)	**(N 23.3632 & E 85.3491)**	**U**	**SH**	**4**	**12.8**	**51**	**3.9**	**107**	**105 - 109**

Table 1: Prevalence and concentration of diclofenac in liver samples from domestic ungulate carcasses sampled in 12 states of India (*contd.*)

State (sampling date)	Site name	Geographic location (GPS reading) (decimal degrees)	Rural (R) / Urban (U)	Dump type	Sampling days (n_d)	Daily carcass Arrival rate	Samples collected (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentration µg/kg
Madhya Pradesh										
(13.02.05 to 04.03.05)	Bhaneka	N 22.6188 & E 80.3912	R	PCD	1	1	1	0	n/a	n/a
	Bhopal	N 23.2991 & E 77.4359	U	MCCD	6	15.3	92	8.7	227	14 - 1,071
	Indore	**N 22.6744 & E 75.9267**	**U**	**MCCD**	**7**	**9.4**	**66**	**16.7**	**199.7**	**17 - 2,156**
	Jabalpur	N 23.2111 & E 79.9558	U	PCD	3	1.7	5	20	211	211
	Pariyat	N 23.2496 & E 79.9735	R	PCD	1	12	12	0	n/a	n/a
	Saliwala	N 23.1081 & E 79.9946	R	PCD	1	2	2	50	2,020	2,020
	Mixi Road (Ujjain)	N 23.1933 & E 75.8033	U	PCD	4	2.5	10	10	28	28
	Somvaria (Ujjain)	N 23.1952 & E 75.7688	U	PCD	4	1.8	7	0	n/a	n/a
Maharashtra										
(09.09.04 to 12.09.04)	Ahmednagar	N 19.0282 & E 74.7422	U	MCCD	1	1	1	0	n/a	n/a
(03.03.05 to 12.03.05)	Bajargoan	N 21.1360 & E 78.7684	R	PCD	1	2	2	0	n/a	n/a
	Mumbai	**N 19.3432 & E 72.8956**	**U**	**MCCD**	**4**	**40.8**	**163**	**6.1**	**196.2**	**15 - 4,135**
	Bhandewali (Nagpur)	(N 21.1525 & E 79.0678)	U	PCD	2	0.5	1	100	1,835	1,835
	Daroga (Nagpur)	(N 21.1525 & E 79.0678)	U	PCD	2	1	2	0	n/a	n/a
	Dairy Farm (Nashik)	N 19.9798 & E 73.7846	U	PCD	3	0.3	1	0	n/a	n/a
	Wada Naka (Nashik)	N 19.9604 & E 73.7929	U	PCD	3	7.3	21	0	n/a	n/a
	Nandwar Naka (Nashik)	N 20.0135 & E 73.8545	U	PCD	2	1	2	0	n/a	n/a
Orissa										
(13.06.05 to 16.06.05)	**Sambalpur**	**N 21.4685 & E 83.9929**	**U**	**SH**	**4**	**13**	**52**	**0**	**n/a**	**n/a**
Punjab										
(01.02.05 to 08.02.05)	Jalandhar	N 31.0091 & E 75.5640	U	PCD	1	2	2	0	n/a	n/a
	Khanikui	N 32.1665 & E 75.5538	R	PCD	2	1.5	3	0	n/a	n/a
	Kuthed	N 32.3047 & E 75.6893	R	PCD	3	0.3	1	0	n/a	n/a
	Ludhiana*	**N 30.9870 & E 75.7745**	**U**	**MCCD**	**4**	**15.3**	**61**	**16.4**	**457.3**	**34 - 1,879**
	Pathankot	N 32.2534 & E 75.6425	U	PCD	2	2	4	25	1,228	1,228
	Sujanpur	N 32.3194 & E 75.6125	R	PCD	2	2	4	25	69	69
	Thariyal	N 32.3429 & E 75.6086	R	PCD	3	0.3	1	0	n/a	n/a
Rajasthan										
(28.06.04 to 18.07.04)	Bikaner	N 27.9676 & E 73.3755	U	MCCD	8	18.8	150	12.7	507.5	15 - 13,723
	Jodhpur	**N 26.3131 & E 72.9065**	**U**	**MCCD**	**7**	**22.7**	**159**	**21.4**	**614.1**	**13 - 4,102**
	Sanchore	N 24.7400 & E 71.6500	R	PCD	3	0.3	1	0	n/a	n/a

Table 1: Prevalence and concentration of diclofenac in liver samples from domestic ungulate carcasses sampled in 12 states of India (*contd.*)

State (sampling date)	Site name	Geographic location (GPS reading) (decimal degrees)	Rural (R) / Urban (U)	Dump type	Sampling days (n_d)	Daily carcass Arrival rate	Samples collected (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentration µg/kg
Uttar Pradesh (27.07.04 to 04.09.04) (27.06.05 to 05.07.05)	Baksi ka talab (Lucknow)	(N 26.8642 & E 80.9319)	U	PCD	4	2	8	12.5	1,107	1,107
	Dubagga (Lucknow)	(N 26.8642 & E 80.9319)	U	PCD	6	6.3	38	7.9	248.2	48 - 2,631
	Ghaziabad	N 28.6393 & E 77.3357	U	MCCD	3	19.7	59	3.4	156.2	18 - 1,356
	Madia (Lucknow)	(N 26.8642 & E 80.9319)	R	PCD	2	3	6	16.7	2,320	2,320
	Meeruth	N 28.9502 & E 77.6826	U	MCCD	7	19.1	134	14.2	697.4	34 - 6,524
	Nivari carcass dump (Aligarh)	**N 27.8735 & E 78.0323**	**U**	**PCD**	**5**	**4.6**	**23**	**26.1**	**185.4**	**28 - 1,855**
	Nivari Slaughterhouse (Aligarh)	N 27.8601 & E 78.0189	R	SH	1	19	19	0	n/a	n/a
	Purvi Din Kheda (Lucknow)	(N 26.8642 & E 80.9319)	R	PCD	4	3	12	8.3	2,948	2,948
	Saharanpur	N 29.9828 & E 77.5422	U	SH	4	37.5	150	1.3	12	11 - 13
West Bengal (28.04.05 to 10.05.05)	Barakpur	N 22.7480 & E 88.3632	R	CCD	3	4.3	13	0	n/a	n/a
	Kalyani	**N 22.9742 & E 88.4850**	**U**	**CCD**	**5**	**3**	**15**	**20**	**815.5**	**459 - 1,976**
	Kolkata	N 22.5608 & E 88.3865	U	PCD	10	6.4	64	9.4	370.9	63 - 2,038
	Siliguri	N 26.7456 & E 88.4563	U	MCCD	2	1	2	0	n/a	n/a

Abbreviations: d_p = prevalence of diclofenac, n_t = total number of samples, n_d = total number of sampling days, n/a = not applicable, GPS = Global Positioning System

Note: Rows highlighted in bold show where the d_p is highest (where sites have >6 samples),

GPS readings in brackets show the location of the city/village but not the exact dump site, whereas those without brackets are specific to dumps.

* An average of 15.3 carcasses were sampled each day, however >50 animals per day were arriving at the site

Geometric mean concentrations were calculated only from those samples with detectable residues

MCCD: Municipal Corporation Carcass Dumps; CCD: Co-operative Carcass Dumps; ACCD: Animal Charity Carcass Dumps; PCD: Private Carcass Dumps; SH: Slaughterhouses

Table 2: Prevalence d_p (%) and concentration of diclofenac in liver samples of domestic ungulate carcasses in 12 states of India, by species, gender, type of death, type of site and age

	Andhra Pradesh				Bihar				Gujarat				Jammu and Kashmir			
	Number of sampes (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentrations µg/kg	Number of sampes (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentrations µg/kg	Number of sampes (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentrations µg/kg	Number of sampes (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentrations µg/kg
	Species: $\chi^2_2 = 8.546$, $p < 0.05$				Species: $\chi^2_1 = 1.712$, $p = 0.191$				Species: $\chi^2_1 = 1.708$, $p = 0.191$				Species: $\chi^2_1 = 0.194$, $p = 0.662$			
Buffalo	**41**	**9.8**	**101.8**	**28-269**	11	0	n/a	n/a	**18**	**11.1**	**252.8**	**86-743**	48	2.1	100	100
Cattle	53	1.9	80	80	**110**	**24.5**	**258.8**	**15-3,582**	39	10.3	1,647	1,150-3,183	**29**	**6.9**	**26.5**	**16-44**
Goat	28	0	n/a	n/a	0	n/a	n/a	n/a	1	0	n/a	n/a	0	n/a	n/a	n/a
Sheep	37	0	n/a	n/a	0	n/a	n/a	n/a	7	0	n/a	n/a	0	n/a	n/a	n/a
Camel	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
Horse	2	50	24	24	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Gender: $\chi^2_1 = 0.511$, $p = 0.475$				Gender: $\chi^2_1 = 6.147$, $p < 0.05$				Gender: $\chi^2_1 = 3.726$, $p = 0.054$				Gender: $\chi^2_1 = 1.091$, $p = 0.296$			
Female	**128**	**4.7**	**76.8**	**24-269**	**83**	**30.1**	**274.1**	**15-3,582**	**34**	**17.6**	**881.8**	**86-3,183**	**41**	**7.3**	**41.3**	**16-100**
Male	32	0	n/a	n/a	38	5.3	126	27-588	31	0	n/a	n/a	36	0	n/a	n/a
Unsexed	1	0	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Type of death: n/a				Type of death: n/a				Type of death: n/a				Type of death: n/a			
Natural	**161**	**3.7**	**76.8**	**24-269**	**121**	**22.3**	**258.8**	**15-3,582**	**65**	**9.2**	**881.8**	**86-3,183**	77	**3.9**	**41.3**	**16-100**
Slaughtered	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Site type: $\chi^2_1 = 3.636$, $p = 0.057$				Site type: n/a				Site type: $\chi^2_2 = 2.102$, $p = 0.349$				Site type: n/a			
ACCD	0	n/a	n/a	n/a	0	n/a	n/a	n/a	**32**	**9.4**	**687.3**	**86-3,183**	0	n/a	n/a	n/a
CCD	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	0	n/a	n/a	0	n/a	n/a	n/a
MCCD	151	2.6	44.5	24-80	0	n/a	n/a	n/a	30	6.7	1,396.2	1,150-1,695	0	n/a	n/a	n/a
PCD	**10**	**20**	**229**	**195-269**	**121**	**22.3**	**258.8**	**15-3,582**	3	33.3	743	743	**77**	**3.9**	**41.3**	**16-100**
SH	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	0	n/a	n/a
	Age: $\chi^2_2 = 3.806$, $p = 0.149$				Age: $\chi^2_2 = 11.196$, $p < 0.01$				Age: $\chi^2_1 = 4.118$, $p < 0.05$				Age: $\chi^2_3 = 7.542$, $p = 0.056$			
IN	15	0	n/a	n/a	47	6.4	388.6	27-3,354	0	n/a	n/a	n/a	42	0	n/a	n/a
IM	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	13	0	n/a	n/a
YPA	75	1.3	24	24	**9**	**55.5**	**170.8**	**59-588**	42	2.4	1,150	1,150	8	12.5	100	0.100
OA	**71**	**7.0**	**97**	**28-269**	65	29.2	270.7	15-3,582	**23**	**21.7**	**836.2**	**86-3,183**	**14**	**14.3**	**26.5**	**16-44**

Table 2: Prevalence d_p (%) and concentration of diclofenac in liver samples of domestic ungulate carcasses in 12 states in India, by species, gender, type of death, type of site and age (*contd.*)

	Number of sampes (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentrations µg/kg	Number of sampes (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentrations µg/kg	Number of sampes (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentrations µg/kg	Number of sampes (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentrations µg/kg
	Jharkhand				**Madhya Pradesh**				**Maharashtra**				**Orissa**			
	Species: $\chi^2_1 = 0.105$, $p = 0.746$				Species: $\chi^2_1 = 3.502$, $p = 0.061$				Species: $\chi^2_1 = 0.016$, $p = 0.898$				Species: n/a			
Buffalo	**18**	**5.6**	**105**	**105**	78	5	268.1	179-705	163	5.5	139.9	15-2,353	7	0	n/a	n/a
Cattle	33	3.0	109	109	**117**	**15.4**	**202.5**	**14-2,156**	**23**	**8.7**	**2,754.6**	**1,835-4,135**	45	0	n/a	n/a
Goat	3	0	n/a	n/a	0	n/a	n/a	n/a	3	0	n/a	n/a	0	n/a	n/a	n/a
Sheep	0	n/a	n/a	n/a	0	n/a	n/a	n/a	4	0	n/a	n/a	0	n/a	n/a	n/a
Camel	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
Horse	0	n/a	n/a	n/a	0	n/a	n/a	n/a	1	0	n/a	n/a	0	n/a	n/a	n/a
	Gender: $\chi^2_1 = 0.306$, $p = 0.58$				Gender: $\chi^2_1 = 5.736$, $p < 0.05$				Gender: $\chi^2_1 = 1.896$, $p = 0.168$				Gender: n/a			
Female	24	0	n/a	n/a	**115**	**16.5**	**225.9**	**14-2,020**	**110**	**8.2**	**228.7**	**15-2,353**	27	0	n/a	n/a
Male	**30**	**6.7**	**107**	**105-109**	80	3.8	147.2	20-2,156	84	2.4	301.6	22-4,135	25	0	n/a	n/a
Unsexed	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Type of death: n/a				Type of death: n/a				Type of death: n/a				Type of death: n/a			
Natural	3	0	n/a	n/a	**195**	**11.3**	**213.1**	**14-2,156**	**194**	**5.7**	**240.5**	**15-4,135**	0	n/a	n/a	n/a
Slaughtered	**51**	**3.9**	**107**	**105-109**	0	n/a	n/a	n/a	0	n/a	n/a	n/a	52	0	n/a	n/a
	Site type: $\chi^2_1 = 1.44$, $p = 0.23$				Site type: $\chi^2_1 = 0.134$, $p = 0.714$				Site type: $\chi^2_1 = 0.028$, $p = 0.867$				Site type: n/a			
ACCD	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
CCD	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
MCCD	0	n/a	n/a	n/a	**158**	**12**	**210.8**	**14-2,156**	**164**	**6.1**	**196.2**	**15-4,135**	0	n/a	n/a	n/a
PCD	3	0	n/a	n/a	37	8.1	228.5	28-2,020	30	3.3	1,835	1,835	0	n/a	n/a	n/a
SH	**51**	**3.9**	**107**	**105-109**	0	n/a	n/a	n/a	0	n/a	n/a	n/a	52	0	n/a	n/a
	Age: $\chi^2_2 = 1$, $p = 0.606$				Age: $\chi^2_3 = 14.099$, $p < 0.01$				Age: $\chi^2_3 = 17.795$, $p < 0.001$				Age: n/a			
IN	0	n/a	n/a	n/a	78	2.6	221	74-660	132	0.8	22	22	1	0	n/a	n/a
IM	3	0	n/a	n/a	25	8	674.5	211-2,156	8	12.5	4,135	4,135	3	0	n/a	n/a
YPA	15	0	n/a	n/a	77	16.9	299.2	14-2,020	**36**	**16.7**	**423.8**	**18-2,353**	18	0	n/a	n/a
OA	**36**	**5.6**	**107**	**105-109**	**15**	**33.3**	**54.8**	**17-194**	**18**	**16.7**	**66.6**	**15-702**	30	0	n/a	n/a

Table 2: Prevalence d_p (%) and concentration of diclofenac in liver samples of domestic ungulate carcasses in 12 states of India, by species, gender, type of death, type of site and age (*contd.*)

	Punjab				Rajasthan				Uttar Pradesh				West Bengal			
	Number of sampes (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentrations µg/kg	Number of sampes (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentrations µg/kg	Number of sampes (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentrations µg/kg	Number of sampes (n_t)	Prevalence (d_p) (%)	Geometric mean Concentration µg/kg	Range of Concentrations µg/kg
	Species: $\chi^2_2 = 2.052$, $p = 0.358$				Species: $\chi^2_2 = 4.011$, $p = 0.134$				Species: $\chi^2_1 = 11.968$, $p < 0.001$				Species: $\chi^2_1 = 0.97$, $p = 0.324$			
Buffalo	21	9.5	145.7	103-206	19	15.8	971.3	409-1,597	396	6.1	382.2	11-6,524	41	4.9	1,650.7	1,337-2,038
Cattle	**53**	**17**	**501.7**	**34-1,879**	**288**	**17**	**583**	**13-13,723**	**51**	**19.6**	**457.7**	**18-5,074**	**52**	**13.5**	**339.3**	**63-1,976**
Goat	0	n/a	n/a	n/a	1	100	53	53	2	0	n/a	n/a	1	0	n/a	n/a
Sheep	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
Camel	0	n/a	n/a	n/a	1	0	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
Horse	2	50	793	793	1	0	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Gender: $\chi^2_1 = 0.673$, $p = 0.412$				Gender: $\chi^2_1 = 0.775$, $p = 0.379$				Gender: $\chi^2_1 = 5.179$, $p < 0.05$				Gender: $\chi^2_1 = 2.937$, $p = 0.086$			
Female	**59**	**18.6**	**400.7**	**34-1,879**	19	15.8	480.1	15-4,248	**241**	**10.8**	**512.8**	**18-5,074**	**63**	**14.3**	**482.3**	**63-2,038**
Male	17	5.9	793	793	**288**	**17**	**991.3**	**13-13,723**	208	4.3	203.8	11-6,524	30	0	n/a	n/a
Unsexed	0	n/a	n/a	n/a	1	0	n/a	n/a	0	n/a	n/a	n/a	1	0	n/a	n/a
	Type of death: n/a				Type of death: n/a				Type of death: n/a				Type of death: n/a			
Natural	**76**	**15.8**	**424.2**	**34-1,879**	**310**	**17.1**	**573.5**	**13-13,723**	**280**	**11.8**	**500.7**	**18-6,524**	**94**	**9.6**	**482.3**	**63-2,038**
Slaughtered	0	n/a	n/a	n/a	0	n/a	n/a	n/a	169	1.2	12	11-13	0	0	n/a	n/a
	Site type: $\chi^2_1 = 0.009$, $p = 0.924$				Site type: $\chi^2_1 = 0.635$, $p = 0.425$				Site type: $\chi^2_2 = 15.85$, $p < 0.001$				Site type: $\chi^2_2 = 0.232$, $p = 0.89$			
ACCD	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
CCD	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	**28**	**10.7**	**815.5**	**459-1,976**
MCCD	**61**	**16.4**	**457.3**	**34-1,879**	**309**	**17.2**	**573.5**	**13-13,723**	193	10.9	604.8	18-6,524	2	0	n/a	n/a
PCD	15	13.3	291.1	69-1,228	1	0	n/a	n/a	**87**	**13.8**	**359.7**	**28-2,948**	64	9.4	370.9	63-2,038
SH	0	n/a	n/a	n/a	0	n/a	n/a	n/a	169	1.2	12	11-13	0	0	n/a	n/a
	Age: $\chi^2_3 = 2.992$, $p = 0.393$				Age: $\chi^2_3 = 14.128$, $p < 0.01$				Age: $\chi^2_1 = 23.31$, $p < 0.001$				Age: $\chi^2_3 = 7.92$, $p < 0.05$			
IN	6	0	n/a	n/a	145	10.3	1,569.7	13-13,723	217	5.5	782.3	34-6,524	58	3.4	482.9	118-1,976
IM	9	0	n/a	n/a	27	7.4	2,399	1,403-4,102	92	2.2	12	11-13	0	n/a	n/a	n/a
YPA	**34**	**20.6**	**625.3**	**34-1,879**	79	21.5	283.1	45-2,804	**74**	**21.6**	**351.8**	**18-5,074**	17	11.8	687	353-1,337
OA	27	18.5	246.4	69-833	**59**	**32.2**	**419**	**15-4,248**	66	7.6	530.4	48-2,948	**19**	**26.3**	**418.4**	**63-2,038**

Note: The rows highlighted in bold show where d_p is highest in each state/category, whilst discounting prevalences based on n < 6 samples

Geometric mean concentrations were calculated only from those samples with detectable residues. For each state statistical tests indicate results for chi-squared analysis of d_p by species, gender, age and site type. n/a indicates such tests are not applicable.

Abbreviations: IN: Infants; IM: Immatuares; YPA: Young prime adults; OA: Old adults

DISCUSSION

The results reported in this paper present information on the prevalence of diclofenac (d_p) at the site and state level, and are therefore more detailed than those given at the national level in the paper by Taggart *et al.* (2007b). This allows detailed comparisons to be made of the contamination of livestock carcasses that are available to vultures. The overall d_p in livestock carcasses across the country was 10.1%, with levels of contamination varying greatly between sites and ranging from 0% to 28.6% for sites where the number of samples collected was >6 (and between 0% and 100% where n_t was <6) and from 3.7% to 22.3% in the 11 (of 12) states where samples tested positive for diclofenac (Taggart *et al.* 2007b). These d_p levels reveal that a substantial proportion of livestock carcasses available to vultures are now contaminated with diclofenac, and at diclofenac concentrations (averaged across the whole carcass) that will cause appreciable mortality to feeding vultures (Green *et al.* 2006). Detailed modelling that incorporates the observed levels of diclofenac contamination found in this study with the estimated mortality rate of vulture populations reveals that the modelled rate of decline matches the rates of population decline observed across India, and that diclofenac is the only factor needed to explain the observed declines (Green *et al.* 2004, 2007). As a consequence, this survey and these studies highlight the urgent need to effectively prevent the veterinary use of this drug.

The observed variation in d_p detected across India may be related to whether the drug is actively promoted/used by veterinary practitioners in any particular area, which may in turn depend on the predominant livestock species treated and the livestock owners' ability to afford treatment for their animals. However, no significant difference was found between the d_p detected in rural and urban areas, as might have been expected if access to veterinary care (and perhaps wealth) were more limited in rural areas.

The d_p in female animals was found to be significantly higher than in males in three states (Bihar, Madhya Pradesh, Uttar Pradesh), and across the country carcasses of female animals showed higher levels of diclofenac contamination than did males (Taggart *et al.* 2007b). Such a bias in treatment may be because farmers are more acutely conscious of the health of active milking animals since they provide an ongoing income resource. Further, Taggart *et al.* (2007b) suggested that such a trend may be evident because lactating females are commonly given NSAIDs in combination with antibiotics to treat mastitis. By age group, adults [young prime adults (YPA) and old adults (OA)] had a higher d_p than subadults [immatures (IM) and infants (IN)] in eight states, which may again reflect the fact that Indian livestock holders (especially farmers) are more 'concerned' about the health of actively milking animals (i.e. mature animals), and therefore the veterinary care of subadults may be comparatively neglected. Moreover, livestock are probably simply more likely to need veterinary treatment with advancing age, injuries and diseases.

This study and that of Taggart *et al.* (2007b) found that d_p varied significantly between livestock species, with overall levels across the country highest in cattle (14.7%) in comparison with buffalo (6.0%), goats (2.3%) and sheep (0%). The d_p was higher in cattle than in other species in the following states: Bihar, Jammu and Kashmir, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Uttar Pradesh and West Bengal. Only Andhra Pradesh, Gujarat and Jharkhand reported higher d_p levels in buffalo. Whether the state level differences are a consequence of differing farming practices is unknown, however, the overall higher d_p in cattle is not surprising given the cultural and economic importance of cattle within India.

The d_p also varied in relation to the type of site sampled, with (nationally) lower levels of diclofenac found at slaughterhouses in comparison with carcass dumps. Although we sampled only five charity dumps (ACCDs) in Gujarat, two (Rajkot Panjarapole and Paragpur Panjarapole) of these contained animals that were positive for diclofenac. These ACCDs are particularly interesting as animals that arrive at such sites are probably generally well cared for prior to death, by charity-employed veterinarians. As these charities work for the well-being of all animals, and not just livestock, they may be receptive to information regarding the dangers of diclofenac to vultures. Consequently, it may be beneficial to target such charity-run sites in order to try to protect any residual local vulture populations.

This study gave us an opportunity to visit a large variety of carcass dumping sites across much of India (more than 80 sites in 15 states), and to interact with those involved in the mechanism of livestock carcass processing. Our interaction with skinners suggests that the decline in vulture numbers across India has also had an adverse impact on the profitability of such sites, and on the health and safety of the people processing livestock carcasses. Skinners believed that the decline in vulture numbers meant that the flesh on the carcasses was being less rapidly consumed, and hence sites were producing more unpleasant odours, and acting as an increased hazard to public health for longer, as the carcasses rotted. This had in turn raised public awareness of these sites and therefore municipalities in many cities were under increasing pressure to change the traditional way of disposing of livestock carcasses. In certain areas, i.e., at Siliguri,

Guwahati, Shillong, Bogaigoan, Nagoan, Tezpur and Tinsukia in north-eastern India the practice was already being replaced by burial. Hyderabad, Ahmedabad and Jabalpur were also set to follow suit, and in Jodhpur a carcass incineration plant had already been established. We also found that at many of the sites where burial was being used, the carcasses were no longer being skinned, and that this was then having a direct impact on the leather and skinning industry in those areas. Skinners encountered during this work suggested that when vulture numbers were high, they cleaned the bones of the skinned carcasses thoroughly and in a matter of minutes, providing high quality clean bones for market. Without vultures, extra labour was required to remove meat from the bones, and the quality of the final cleaned bone was never as good as when cleaned by vultures. Traces of meat left on bones decayed over time and turned the bones yellow, generating a low-grade product in the bone market. Skinners reported that the price of bone had reduced drastically over recent years.

In total we spent 169 days at 67 different carcass sites, however, in this time we only recorded endangered *Gyps* vultures on three days, and only a very small number of birds were observed at the three sites where they were recorded (i.e. *G. bengalensis* at Dabala Panjarapole ACCD (seven individuals) and Bhachau MCCD (22 individuals) in Gujarat, and two *G. indicus* at Bikaner MCCD in Rajasthan). Older skinners often stated that only a couple of decades earlier, there used to be hundreds of *Gyps* vultures flying around carcass dumps. Unfortunately, if the emerging trend towards livestock burial continues, as it probably will, even eradicating diclofenac will not, on its own, permit wild vulture's numbers to recover to the high levels historically observed in India. Although not currently a significant problem in most areas, a lack of food availability may become an issue in future decades as India continues to rapidly develop its waste management and public health structure and capacity.

In agreement with Prakash *et al.* (2003), our study clearly shows that food scarcity is not a driving force behind the rapid vulture declines being observed in India today. Among the 63 carcass dumps of the 67 sites sampled in this study, the overall mean average carcass intake rate was 7.47 ±0.58 animals per day, with a maximum average intake rate of 41 carcasses per day recorded at Mumbai and more than 50 per day at Ludhiana, Punjab. Despite these high numbers of carcasses, sightings of *Gyps* vultures were extremely infrequent. If the overall mean carcass intake rate (for all 67 sites) of 6.2 animals per day is continued throughout a year, then a typical site would take around 2,270 animals per year, whereas a large site such as at Mumbai may take in nearly 15,000 carcasses (if the daily intake rate of 41 carcasses/day is accurate). Cattle and buffalo formed 95% of the 1,848 carcasses we observed. Since the edible tissue of these species constitutes 75.5% of the total mass (Green *et al.* 2006), and the average mass of the Indian Cattle *Bos indicus* is around 202 kg, a typical carcass dump could provide nearly 3,29,000 kg of edible tissue (edible mass = [2270 x 0.95] x [202 x 0.755]). An individual *Gyps bengalensis* typically requires around 0.341 kg of food per day (Swan *et al.* 2006), which represents 125 kg per year. If all the edible matter at a dump was available to vultures, an average carcass dump could potentially support a vulture population of 2,600 birds, and the Mumbai dump could support over 17,000 birds. These calculations are not entirely realistic, as even in past decades vultures would not have had access to all the edible tissues available, given the presence of other scavengers and decay. However, given the fact that we only visited a small subset of the total number of carcass dumps across India, the availability of carcasses could still easily support a very large national population of vultures, and these calculations demonstrate that lack of food is certainly not, currently, a significant factor for vultures.

Our fieldwork also revealed that Black Kite (*Milus migrans*) and Cattle Egret (*Bubulcus ibis*) are now the most common avian scavengers seen on carcass dumps, with up to 80 Black Kites observed at Bikaner and 300 cattle egrets at Ludhiana MCCDs. Given the toxicity of NSAIDs to a range of scavenging birds (Cuthbert *et al.* 2006a), these observations raise serious concerns about the potential impact of diclofenac contamination on other bird species scavenging at carcass dumps. This is especially so for Egyptian Vultures (*Neophron percnopterus*) and Red-headed Vultures (*Sarcogyps calvus*), which are rapidly decreasing in numbers (Cuthbert *et al.* 2006b). However, there are considerable inter-specific differences in the toxicity of NSAIDs among birds (including diclofenac; Rattner *et al.* 2008); hence not all species present at carcass dumps may be negatively affected. We also noted an abundance of feral dogs (*Canis familiaris*) at the majority of sites visited, and skinners have reported that there has been an increase in the numbers of feral dogs over the last 5 years. Feral dogs were seen at all 67 sites visited for sampling, with a maximum of 88 counted at Rajkot MCCD in Gujarat. Increased numbers of feral dogs may obviously increase the risk of rabies transmission to humans in India, already a very important issue in the country (Sudarshan *et al.* 2007). With very high numbers of feral dogs present at carcass dumps (>1,200 at one site; Prakash *et al.* 2003), competition for feeding resources (either direct and/or interference competition) may also hinder the return of vultures to such feeding areas. Supporting this, observations at the ACCD at

Poladiya Panjarapole in Kutch suggested that vultures either fed upon carcasses in the early morning (between 0500 and 0700 hours), or waited, sitting at a distance from the dump until dusk, when the dumps were free of feral dogs (of which there were around 25 at this site).

In conclusion, this study provides a detailed analysis of the site-specific prevalence of diclofenac in India and of the factors that influence prevalence at a local scale. The data will be of interest in the future, as longer-term assessments are made of the prevalence of diclofenac available to vultures in the environment, and the effectiveness of the diclofenac ban. Assessing the effectiveness of the diclofenac ban should incorporate measurement of diclofenac prevalence across the country (as undertaken in this study) as well as modelling the impact of the measured concentrations upon vulture populations as undertaken by Green *et al.* (2007). This study suggests that diclofenac is particularly heavily used in certain parts of India and an understanding of why this is the case may aid efforts to ensure that an effective ban is implemented. Effective long-term monitoring, utilising this baseline data set, is now imperative in order to assess the effectiveness of the ban, using a re-sampling schedule based on the methods detailed in this study.

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THE WATERBIRDS OF PULICAT LAKE, ANDHRA PRADESH-TAMIL NADU, INDIA, INCLUDING THOSE OF THE ADJOINING WETLANDS AND HERONRIES

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This paper provides an account of the waterbirds of Pulicat lake based primarily on findings of a 3-year study (December 2004 to November 2007) that covered the entire expanse of the Pulicat lake and supplemented by records of earlier workers. It also describes the waterbirds occurring in the adjoining heronries and freshwater wetlands, thus providing a comprehensive account of the avifauna of the Pulicat lake area. The status, distribution and abundance of 113 waterbird species (both resident and migratory) from the Pulicat lake area are discussed.

Key words: waterbirds, Pulicat lake, Nelapattu, Sriharikota, Kudiri tank, heronries

INTRODUCTION

Pulicat is the second largest brackish water lagoon after Chilika (Orissa) in India and one of the most important refuges for waterbirds in southern India (Scott 1989; Perennou and Santharam 1990; Santharam 1993, 1998; Samant and Rao 1996; Rao 1998; Balachandran 1998; Anon 1993; Manakadan and Kannan 2003). There are also a number of heronries and wetlands in the Pulicat area (Nagulu 1983; Krishnan 1990; Perennou and Santharam 1990; Ramakrishna 1990, 1996; Santharam 1993, 1998; Philip 1995; Philip *et al.* 1998; Subramanya 1996a, 1996b; Samant and Rao 1996; Sharma, and Raghavaiah 2000, 2002; Manakadan and Kannan 2003; Manakadan and Sivakumar 2004a; Kannan and Manakadan 2005; Sivakumar and Manakadan 2005). Because of its importance to waterbirds, Pulicat is identified as an Important Bird Area (IBA) site of India by the BirdLife International and the Bombay Natural History Society (Islam and Rahmani 2004). For these and other reasons, Pulicat has also been proposed for inclusion as a Ramsar Site by the Wetlands International.

Almost all the previous available information on the waterbirds of Pulicat is based on the studies and surveys from its central region (i.e., along the Sullurpet-Sriharikota road stretch and Tada area). The only study that covered the entire expanse of Pulicat lake pertains to a single species, the Spot-billed Pelican *Pelecanus philippensis* (Manakadan and Kannan 2003; Kannan and Manakadan 2005). Hence, there were lacunae in the information on the distribution, species composition, abundance and conservation issues related to the waterbirds in the other parts, and this was the genesis of the study taken up by the first two authors (Manakadan and Kannan 2007). In order to obtain a more complete profile of the waterbirds of the Pulicat area, we also collected data on the heronries and more important wetlands in the area. All the data collected were supplemented with published and unpublished information of earlier workers: Prakash Rao and K.K. Mohapatra had worked in the Pulicat area from 1990 to 1994 (Samant and Rao 1996; Rao 1998; Balachandran 1998). S. Sivakumar had worked in the Pulicat area from 2001 to 2003 (Manakadan and Sivakumar 2004a). V. Santharam birded in the Pulicat area during 31 visits spread over a period of about 27 years and was a part of the BNHS Bird Migration Project in the Pulicat area from January 1990 to April 1990.

STUDY AREA

Pulicat lake (13° 24'-13° 47' N; 80° 03'- 80° 18' E) is situated in the states of Andhra Pradesh and Tamil Nadu in Nellore and Tiruvallur districts respectively. It encompasses an area of 720 sq. km (Scott 1989), of which 84% falls in Andhra Pradesh and the remaining 16% in Tamil Nadu (Fig. 1). The lagoon is about 60 km in length and its breadth varies from 0.2 to 17.5 km. The lake is comparatively shallow with an average depth of a little over a metre, with a north to south and west to east slope. The maximum depth of the lake is at the southern part, *c.* 7 m. During the dry season, water is generally present only in the southern lagoon part of Pulicat and near the two openings into the Bay of Bengal in the northern areas. The other areas may receive inflows from the

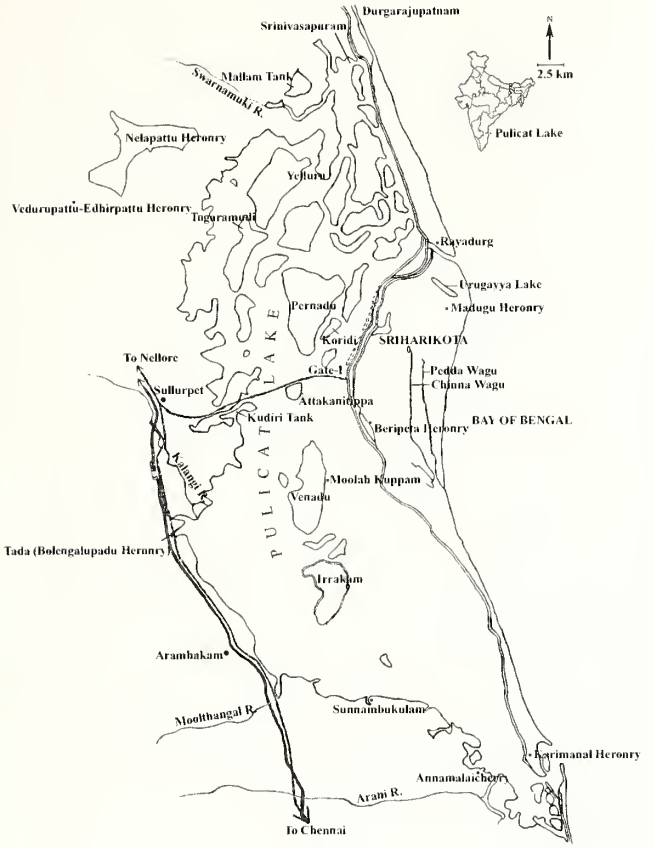

Fig. 1: Pulicat lake and its adjoining areas

Bay of Bengal during spring tides, especially when aided by strong winds.

Pulicat has three major openings into the Bay of Bengal, the largest being at the southern end of the Sriharikota Island, another at the northern tip of the Sriharikota Island and the third at the extreme northern part near Durgarajupatnam. The Buckingham Canal traverses in a north to south direction along the eastern edge of Pulicat and along Sriharikota island. The rivers Swarnamukhi and Kalangi in the northern part and the Arani and Moolthangal in the southern part drain into the lake during the monsoon season, causing an increase in water levels and a lowering of salinity. Pulicat has 20 islands, the largest being Sriharikota Island (*c.* 181 sq. km) at its eastern edge, which serves as the base for India's spaceport, the Satish Dhawan Space Centre-SHAR (SDSC-SHAR). The other large islands are Pernadu, Irrakam and Venadu. These islands have deposits of sub-fossilised lime shell. The islands are of recent origin in the geological time-scale, and are nothing more than low ridges of sand with the marine and aeolian deposits rising only a few metres above the sea level. Some of these islands are now connected to one another and/or to the mainland by roads cutting into the lake.

The rainfall in the region is largely from the North-east Monsoon (October-December). Very little rainfall is received during the South-west Monsoon (June-September). Pulicat is often exposed to extreme weather events like depressions and cyclones, usually in the early part of May and October, during the onset of the two monsoons. The annual rainfall is *c.* 1,200 mm. December to February is the winter season, with temperatures as low as 10 °C. March to September is the summer season, with temperatures soaring over 40 °C. A cool breeze blowing from the sea and from Pulicat gives some relief during the summer months. The wind throughout the major part of the year is from the south-west. The relative humidity is lowest during May (18%), while the maximum (99%) is recorded during October (source: Meteorological Department, SDSC-SHAR).

Paleobotanical studies show that a luxuriant mangrove forest flourished in Pulicat between 1450 and 1800 A.D., the peak being between 1450 and 1590. The remnants of mangrove vegetation are still seen in small patches in some areas of Pulicat, which is otherwise now bereft of mangrove vegetation. Sriharikota Island, well protected as it is a restricted area under the control of the Indian Space Research Organisation (ISRO), has remnants of the tropical dry evergreen forest of considerable botanical interest. On the other islands in the lake, where protection is negligible, the exotic *Prosopis chilensis* has invaded many areas. In the elevated mudflats, succulent halophytes, such as *Anthrocnemum indicus*, *Sesuvium portulacastrum*, *Salicornia brachiata*, *Suaeda maritima*, *Suaeda monoica* and *Suaeda nudiflora* occur. Submergent macrophytes of *Enteromorpha*, *Hypneae*, *Ulva*, *Halophila* and *Enhalus* occur in the southern lagoon part of Pulicat lake (Anon 1908; Hornell 1908; Chacko *et al.* 1953; Blasco and Legris 1973; Joel 1973; Kaliyamurthy 1972, 1973, 1974; Paul Raj 1976; Srinivasan and Pillay 1972; Raman *et al.* 1977; Thangavelu 1983; Oswin 1987; Scott 1989; Suryanarayana *et al.* 1989, 1998; Krishnan 1990; Kasappa 1991; Anon 1993; Ramesh 1994; Panini 1996; Sanjeeva Raj 1995-96, 1996; Vaz and Banerjee 1997; Manakadan and Kannan 2003, 2007; Manakadan and Sivakumar 2004a).

There are a number of water bodies and heronries along the western edges of Pulicat and the islands in Pulicat lake, some of which are important for migratory and resident waterbirds and where bird censuses were carried out during this study or earlier studies as follows.

Kudiri Tank: Kudiri Tank (20 ha) is located along the Sullurpet-Sriharikota road *c.* 4 km from Sullurpet. It is a shallow freshwater tank and turns brackish as it dries. The tank belongs to the Irrigation Department of Sullurpet Mandal. The major vegetation is of reed beds. The tank is surrounded by agricultural fields and is used for irrigation.

Koridi: Koridi tank (3.3 ha) is situated in Pernadu Island of Pulicat lake near Koridi village. Koridi is a shallow wetland, which becomes brackish as it dries due to its proximity to Pulicat lake. The tank has water till winter and has reed beds. The tank is surrounded by agricultural fields, which draw water from the tank.

Mallam Tank: Mallam tank (93 ha) is located in the northern part of Pulicat lake area near Mallam, a small town. The depth of the tank is about 2 m. It is a typical freshwater tank under the administration of the Irrigation Department. The major vegetation of the tank is the exotic *Ipomoea carnea*. Along the bunds, there are large trees of *Acacia nilotica*, *Azadirachta indica* and *Borassus flabellifer*.

Urugayya Lake: Urugayya lake, also known as Choladoruvu, is situated in the north-eastern part of Sriharikota Island. It has an expanse of about one square kilometer and is more or less perennial, having dried on only two occasions during the last five decades. The water is clear and brackish, and devoid of aquatic vegetation and has a maximum depth of 4 m. The salinity increases considerably during the summer months averaging that of sea water. Almost freshwater conditions prevail during the peak monsoon season. The excess water of Urugayya flows into the Bay of Bengal during the monsoon season via the Sateneru-Sidimuthu Kayya.

Pedda Wagu and Chinna Wagu: Pedda Wagu is the largest stream in Sriharikota Island, originating from the north-central part of the Island, it flows north to south and then turns eastwards to flow into the Bay of Bengal, traversing a distance of 15 km. The Chinna Wagu flows in a north to south direction parallel to the Pedda Wagu for about 9 km and has no outlet. Both the wagus have dense submergent and emergent aquatic vegetation (e.g., *Hydrilla*, *Chara*, *Typha angustifolia* and *Nymphaea* spp.), with many stretches bordered by canebrakes. Trees that withstand waterlogging such as *Barringtonia acutangula*, *Terminalia arjuna* and *Pongamia pinnata* occur along its banks or at silted sites. The Pedda Wagu generally dries up during the dry season, except for the small stretch at the end of its course and in a few deeper portions. The Chinna Wagu generally dries up completely during summer.

Nelapattu: Nelapattu Bird Sanctuary is situated about 10 km from the north-western border of Pulicat lake. The Sanctuary encompasses an area of 458.92 ha, of which 82.56 ha constitute the tank area. The tank and its bund have *Barringtonia acutangula* and a few other tree species as nest trees. The Nelapattu Pelicanry is very old, and the birds were reported to be nesting in Nelapattu village initially before shifting to the Nelapattu tanks (Nagulu 1983).

Vedurupattu-Edhirpattu: Vedurupattu-Edhirpattu Heronry, also referred to as either Vedurupattu or Edhirpattu, is situated 12 km from the Nelapattu Pelicanry. Vedurupattu and Edhirpattu are two adjoining villages along the Kalangi river, where the birds nest on *Azadirachta indica*, *Ficus* sp., *Acacia nilotica* and *Borassus flabellifer*. This heronry is protected by the villagers and Forest Department (Ramakrishna 1990, 1996).

Tada (Bolengalupadu) Heronry: Tada Heronry is situated at the outskirts of Tada (a small town 4 km south of Sullurpet on NH-5), which is witnessing rapid growth since the beginning of this century after declaration of the region as a Special Economic Zone by the Andhra Pradesh Government. The heronry now consists of only one of the original three *Ficus* trees.

Sriharikota heronries: There are three heronries in Sriharikota, the Madugu, Beripeta and Karimanal heronries. The Madugu Heronry is a mixed species heronry situated in the northern part of the Island and has a riparian forest-thicket vegetation with dense canebrakes. Beripeta is in the central region and consists of riparian forest with tall trees predominantly used by the Painted Storks *Mycteria leucocephala*. The Karimanal Heronry, at the southern end of the Island, a mixed species colony, was earlier situated in a lowland area on casuarina saplings, but the birds have shifted to nearby *Ficus* tree after the casuarina dried up (Manakadan and Sivakumar 2004a; Sivakumar and Manakadan 2005).

METHODS

This paper is primarily based on records kept by the first two authors on the waterbirds of the Pulicat lake and some of the adjoining wetlands and heronries. Their observations were made during regular field visits and systematic census conducted over three years (December 2004 to November 2007). Records obtained during two earlier projects in which the first two authors were involved (Manakadan and Kannan 2003; Manakadan and Sivakumar 2004a) and published or unpublished literature or data of other workers were also accessed for the species accounts.

RESULTS AND DISCUSSION

A total of 77 species of waterbirds were recorded in the Pulicat lake area (inclusive of those in the adjoining wetlands and heronries) during the study. Additionally, another seven species, with all except one recorded in the wetlands of Sriharikota Island, were recorded during the earlier two projects in which the first two authors were involved. Of the overall total of 84 species recorded, 23 species were primarily freshwater species and were not recorded in Pulicat lake but in the adjoining wetlands and

heronries, as were some of the other species recorded by earlier workers. Twenty-nine species recorded by earlier workers were not recorded during the study period, many of these being rare one time records or species captured only during bird banding exercises. With one new species, the Black-bellied Tern *Sterna acuticauda*, recorded during this study and taking into consideration the records of other workers, the checklist of waterbirds of the Pulicat lake area comprises 113 species. Given below are the accounts of 113 species of waterbirds reported from Pulicat lake and in the adjoining wetlands and heronries.

Abbreviations used: R = Resident, with or without breeding records. WM = Winter Migrant, species that breeds in the Palaearctic region/Himalaya during spring and that winters in the Indian subcontinent. SM = Seasonal Migrant, an 'Indian species' that occurs seasonally in the Pulicat area. V = Vagrant, a species recorded outside its normal distributional range. VC = Very Common, sightings possible on almost all days in a year/season in suitable habitats. C = Common, sightings of about once a week in a year/season in suitable habitats. O = Occasional, about one sighting fortnight/month in a year/season in suitable habitats. Ra = Rare, fewer than five sightings per year or three sightings a season. VRa = Very Rare, record based on only one or two sighting during this or earlier projects. ? = Status Uncertain.

Little Grebe *Tachybaptus ruficollis* R C

The Little Grebe is common in the freshwater wetlands of the Pulicat lake area. It was largely seen during September to January in the Kudiri and Mallam tanks. Around 20-30 birds were regularly seen in the Kudiri and Nelapattu tanks, with breeding activity recorded. Breeding had also been reported in Nelapattu by Philip *et al.* (1998) and Santharam (unpublished data). In Sriharikota, the species occurs and breeds in the Pedda and Chinna Wagus (Samant and Rao 1996; Manakadan and Sivakumar 2004a).

Spot-billed Pelican *Pelecanus philippensis* R VC

The Spot-billed Pelican is a common species in Pulicat lake and breeds in the Nelapattu Heronry. The breeding population was 200+ pairs during 2001-2003 (Manakadan and Kannan 2003) and was around 500+ pairs during this study. A stray record of breeding (two nests) had been reported from the Vedurupattu-Edhirpattu Heronry (Ramakrishna 1990). Large congregations are mainly seen in Pulicat lake during the onset of breeding in October; otherwise pelicans occur in smaller flocks or singly. The birds also frequent the larger water bodies around Pulicat lake, but avoid those with dense aquatic vegetation. *See* Manakadan and Kannan (2003) for more details of the Spot-billed Pelican in Pulicat-Nelapattu.

Little Cormorant *Phalacrocorax niger* R VC

The Little Cormorant is a breeding resident and was seen throughout the year in Pulicat and in all the adjoining freshwater water bodies. It breeds in heronries in Nelapattu, Sriharikota (and bred till the 2001-2002 breeding season in Tada). Santharam (unpublished data) recorded 92 nests at Vedurupattu-Edhirpattu in January 1988. An extremely large count of 3,445 birds (including 247 chicks) was recorded in Nelapattu in March 1997 by Philip *et al.* (1998). The number of breeding pairs recorded during our study at Nelapattu ranged from 225 in 2005-2006 to 113 in 2006-2007. Sivakumar and Manakadan (2005) reported *c.* 300 nests in the Karimanal Heronry in Sriharikota Island.

Indian Shag *Phalacrocorax fuscicollis* R Ra

The Indian Shag is an uncommon species in the Pulicat lake with only a record of 10 individuals obtained near Togaramudi in the northern part of Pulicat lake in February 2006. A few sightings were reported from Kudiri Tank by the Forest Department. Manakadan and Sivakumar (2004a) had one record of three birds in Urugayya Lake (Sriharikota Island) from 2001 to 2004. Though rarely seen in Pulicat Lake and the other wetlands, up to 151 pairs were recorded to nest in Nelapattu during the study period. Earlier records include *c.* 1,200 birds during the 1987-88 breeding season (Perennou 1990; Perennou and Santharam 1990) and 1,384 birds in January 1991 (Santharam, unpublished data).

Great Cormorant *Phalacrocorax carbo* V VRa

The only record of the Great Cormorant in the Pulicat lake area is by Perennou and Santharam (1990) reporting two non-breeding birds in Nelapattu in January 1989. The species appears to be a vagrant to the area.

Oriental Darter *Anhinga melanogaster* SM? Ra

There are no reports on the occurrence of the Oriental Darter in Pulicat lake, and it has been recorded only in the adjoining wetlands. Two to three birds were regularly seen in Nelapattu during the 2000-2001 breeding season, but the only sighting in Nelapattu after that was of a single bird in January 2007. Manakadan and Sivakumar (2004a) recorded three darters in April 2002 in the Madugu Wagu and solitary birds during December 2002 and May 2004 in the Malliplate (Mavalam) Wagu of Sriharikota Island. A solitary bird was sighted in the Malliplate Wagu during August 2007 (B. Senthil Murugan pers. comm.). Santharam's (unpublished data) records for Nelapattu were two birds each in January 1991 and 1996, and four birds including a juvenile in January 2003.

Lesser Frigatebird *Fregata ariel* V VRa

The only record of the Lesser Frigatebird, a pelagic species, was of a female in Sriharikota Island in July 1991 (Rao and Mohapatra 1993a, 1993b; Samant and Rao 1996). The Lesser Frigatebird has also been reported from Chennai, about 40 km to the south of the Pulicat lake (Santharam 1982).

Little Egret *Egretta garzetta* R VC

The Little Egret is a very common species occurring throughout the year in Pulicat, and the other wetlands and breeding in the heronries in the Pulicat area. Past records include 20+ nests in January 1988 (Perennou and Santharam 1990) and 34 nests in January 1991 (Santharam, unpublished data) in the Vedurupattu-Edhirpattu Heronry, 219 adults and 118 chicks in Nelapattu (Philip *et al.* 1998) and *c.* 150 nests in the Sriharikota heronries during the 2001-2002 breeding season (Sivakumar and Manakadan 2005). Samant and Rao (1996) described it as 'one of the commonest egret species encountered in all water bodies'. The birds were mostly seen in small flocks near drying pools and temporary wetlands, sometimes occurring in large congregations of 1000+ birds where fish get trapped in shallows.

Western Reef-Heron *Egretta gularis* SM? VRa

Only one individual was sighted in the northern part of Pulicat near Pambali during November 2006. Rao (1998) described it as 'uncommon in most areas' and reports of a sighting from the northern areas of Sriharikota Island and 'up to 5 individuals recorded at a time in Pulicat lagoon'. Manakadan and Sivakumar (2004a) did not record the species. Santharam (unpublished data) recorded it in small numbers on a few occasions in Pulicat lake.

Grey Heron *Ardea cinerea* R VC

The Grey Heron is relatively common throughout the year in Pulicat, feeding especially in association with the Painted Stork, Large Egret and Spot-billed Pelican. The highest count of a congregation during this study was of 103 birds in 2007. It has been reported breeding in the Tada and Vedurupattu-Edhirpattu heronries with up to 30+ nests in Tada and 18 nests in Vedurupattu-Edhirpattu (Perennou and Santharam 1990; Ramakrishna 1990; Santharam,unpublished data), but does not usually breed in Nelapattu. A new breeding site is in Sriharikota Island, where Manakadan and Sivakumar (2004a) reported a total of 14 breeding pairs in the three heronries.

Purple Heron *Ardea purpurea* R O

The Purple Heron is a solitary and uncommon species, seen only in thickly vegetated freshwater wetlands around Pulicat lake. It was occasionally sighted from the wagus of Sriharikota Island (Samant and Rao 1996; Rao 1998; Manakadan and Sivakumar 2004a). The only breeding record in the areas is of a nest at Nelapattu in August 1996 (Santharam, unpublished data).

Great Egret *Egretta alba* R VC

The Great Egret is a common species in Pulicat with high counts of around 300 occasionally, and once of 717 birds. The only known breeding record of the species is of six nests from the Karimanal Heronry in Sriharikota (Manakadan and Sivakumar 2004a; Sivakumar and Manakadan 2005).

Intermediate Egret *Egretta intermedia* R O

The Intermediate Egret was not recorded in Pulicat lake during this study, but a few were occasionally recorded in freshwater tanks. Manakadan and Sivakumar (2004a) also recorded the species only in freshwater habitats in Sriharikota but not in Pulicat lake. Samant and Rao (1996) and Rao (1998) describe its occurrence in Sriharikota Island as a 'rather uncommon in most water bodies but often seen in good numbers towards February-March when individuals shift to the island from Pulicat'. The only breeding records of the species are of a nest in the Karimanal Heronry in Sriharikota (Manakadan and Sivakumar 2004a; Sivakumar and Manakadan 2005) and of *c.* 10 nests in Nelapattu in January 2003 (Santharam, unpublished data).

Eastern Cattle Egret *Bubulcus ibis* R O

The Eastern Cattle Egret is a common species largely recorded in November and December. It is mostly seen in ploughed fields following livestock. It becomes uncommon during summer. The population visiting the Pulicat area each year is probably in the range of 200 to 400 birds. A few birds (10 pairs during the 2005-2006 breeding season and 12 pairs during the 2006-2007 season) were recorded to breed at Nelapattu during this study. Philip *et al.* (1998) had recorded 116 adults and 36 chicks during March 1997.

Indian Pond-Heron *Ardeola grayii* R VC

The Indian Pond-Heron is a common species in Pulicat and the other wetlands, foraging mostly at the edges of water bodies. They shift to wet agricultural fields when Pulicat and the other water bodies dry up. A large congregation of 104 birds was recorded during March 2006 and another of 161 birds during January 2007. There are no records of the species nesting in the Pulicat area.

Striated Heron *Butorides striata* R VRa

Only one bird was sighted during May 2005 and one in December 2007 near Srinivasapuram in the northern part of Pulicat. Rao (1998) obtained two sightings from Sriharikota Island during his 3-year study, and B. Senthil Murugan (pers. comm. in 2007) recorded one in the Beripeta Heronry (Sriharikota) during February 2007. Santharam (unpublished data) had a sighting of a bird in January 1998 in Sriharikota.

Black-crowned Night-Heron *Nycticorax nycticorax* R O

The Black-crowned Night-Heron was not recorded from Pulicat lake, but *c.* 200 pairs breed in Nelapattu. It also occurs in Sriharikota Island (Rao 1998) and probably breeds there (Manakadan and Sivakumar 2004a; Sivakumar and Manakadan 2005). Santharam (1982) recorded an adult Night Heron killed by a Booted Eagle (*Hieraeetus pennatus*).

Yellow Bittern *Ixobrychus sinensis* R VRa

The Yellow Bittern was not recorded during the study. Rao (1998) and Manakadan and Sivakumar (2004a) had one sighting each from the Pedda Wagu area in Sriharikota Island. Santharam (unpublished data) had three sightings of the species: two birds in February 1990 in Sriharikota, and four birds in Nelapattu and two birds at Kudiri Tank in August 1996.

Chestnut Bittern *Ixobrychus cinnamomeus* R Ra

The Chestnut Bittern was recorded by Manakadan and Sivakumar (2004a), recording solitary birds around the Beripeta Heronry and Urugayya lake in Sriharikota in June and October 2002, respectively. B. Senthil Murugan (pers. comm. in 2007) obtained a number of sightings in dense vegetation near the Malliplate (Mavalam) Wagu culvert in Sriharikota. It probably breeds on the island. Santharam (unpublished data) recorded three birds at Nelapattu (including a juvenile) during August 1996.

Black Bittern *Dupetor flavicollis* R O

The Black Bittern was not recorded during the study. (Rao 1998) obtained a few records in Sriharikota Island. Manakadan and Sivakumar (2004a) obtained two records each along the Buckingham Canal and Urugayya lake in Sriharikota Island. B. Senthil Murugan (pers. comm. in 2007) obtained a sighting in dense vegetation near the Malliplate (Mavalam) Wagu culvert in Sriharikota Island. Santharam (unpublished data) obtained two sightings of single birds from Sriharikota Island (during March 1990 in Beripeta and April 1990 in Pedda Wagu).

Eurasian Bittern *Botaurus stellaris* WM VRa

The only record of the Eurasian Bittern is by Rao (1998), who sighted a bird from the marshy area of Pedda Wagu near Ravanappa Chatram in Sriharikota during March 1991.

Painted Stork *Mycteria leucocephala* R VC

The Painted Stork is a very common resident species in Pulicat and in the other larger wetlands. The highest count obtained during this study was 645 birds off Beripeta during August 2006. The species bred in some years in the Vedurupattu-Edirpattu Heronry (*c.* 15 pairs) during this study, but this heronry had earlier supported a larger number of nests: 200 nests (Ramakrishna 1996), 273 nests (Philip *et al.* 1998) and 135 nests (Santharam 1998). It appears that the birds have almost totally shifted to the heronries in Sriharikota since the beginning of this century, with regular breeding in the Beripeta heronry supporting more than 200 pairs.

Asian Openbill *Anastomus oscitans* R C

The Asian Openbill is a breeding migrant arriving in September and departing by April. Being a freshwater species, it is rarely seen in Pulicat lake, and the few records from Pulicat lake were after rains. Rao (1998) and Manakadan and Sivakumar (2004a) occasionally encountered the species in the freshwater bodies of Sriharikota Island. It breeds in Nelapattu, numbering 300 to 350 pairs.

Woolly-necked Stork *Ciconia episcopus* V VRa

The only record of the Woolly-necked Stork during this study was a bird sighted in February 2001 at the outskirts of Venadu village, an island in Pulicat. Santharam (unpublished data) recorded a bird flying over Nelapattu during December 1987.

White Stork *Ciconia ciconia* WM VRa

Rao and Mohapatra (1993a) list the White Stork, but without providing details. We recorded a pair in a freshwater wetland north of Tada town amidst a flock of foraging Asian Open-bill Stork in January 2005.

Glossy Ibis *Plegadis falcinellus* SM Ra

About 200-250 Glossy Ibis were recorded annually during November and December in crop fields adjacent to Pulicat and in the Kudiri Tank. A flock of 19 birds was seen in the Penubakkam Badava in Sriharikota Island in February 2002 (Manakadan and Sivakumar 2004a). Santharam (unpublished data) did not record the species in Pulicat before 1988, but recorded it subsequently on four occasions in numbers ranging from 10 to 144 birds.

Black-headed Ibis *Threskiornis melanocephalus* R O

The Black-headed Ibis breeds in Nelapattu and was

occasionally recorded in the Pulicat area, freshwater wetlands and also inundated crop fields. Rao (1998) and Manakadan and Sivakumar (2004a) reported a few sightings from Sriharikota Island. The maximum number of breeding pairs observed at Nelapattu during this study was 198 in 2006. Santharam (unpublished data) feels that the species is getting to be commoner in Nelapattu in recent years: less than 100 birds used to be seen in the early 1980s, and since 1997, there are sightings of over 200 individuals, plus a record of 250 birds in the Kudiri tanks in February 1990.

Indian Black Ibis *Pseudibis papillosa* V VRa

The occurrence of the Indian Black Ibis in Pulicat lake is cited by Rao and Mohapatra (1993a) without providing details. B. Senthil Murugan and J. Patrick David (pers. comm. in 2007) sighted a flock of 40 birds in a paddy field near Sullurpet in February 2007.

Eurasian Spoonbill *Platalea leucorodia* R/SM? Ra

The Eurasian Spoonbill was occasionally recorded in Pulicat and other freshwater wetlands in small numbers, with the largest flocks of 170 to 200 birds recorded during April and May 2006. Rao (1998) described the species as rare on Sriharikota Island, and Manakadan and Sivakumar (2004a) recorded the species once from Urugayya and Pulicat lakes. The species was also seen in Nelapattu in small numbers of 10 to 15 birds during the breeding season. There are no recent records of the species breeding in the Pulicat area, but it had been recorded nesting in small numbers at Nelapattu in the early 1980s (Santharam, unpublished data) and Ramakrishna (1990) had reported three or four nests in Vedurupattu-Edhirpattu.

Greater Flamingo *Phoenicopterus ruber* SM VC

The Greater Flamingo is a seasonal migrant seen largely in winter, but some birds can be found almost throughout the year. The numbers counted during this study were *c.* 8,000 in 2005, 15,000 in 2006 and 13,000 in 2007. Krishnan (1990) reports 3,000+ flamingos in Pulicat lake in 1983, and Rao and Mohapatra (1993a) cite figures ranging from 2,000+ to 5,000+ from 1988 to 1992 for both the flamingo species together. Santharam's (unpublished data) counts include 4,000 birds (including juveniles) in July 1996, 9,000 birds in January 1998, and 8,000 birds in December 2000.

Lesser Flamingo *Phoeniconaias minor* SM Ra

The Lesser Flamingo was infrequently recorded in Pulicat. The highest count was of *c.* 3,000 birds in May 2007. Manakadan and Sivakumar (2004a) sighted it occasionally during fortnightly censuses in the southern part of the lagoon, with a maximum of *c.* 1,000 birds recorded during 2003-2004. Birds were not recorded during the 2002-2003 season, a low rainfall year. Rao (1998) found the species to be rare in Pulicat lake. Santharam (unpublished data) recorded 5,300 birds in January 1988, 300 birds in August 1996 and 100 birds in December 1997.

Lesser Whistling-Duck *Dendrocygna javanica* R VRa

The Lesser Whistling-Duck was not recorded during this study, but the species breeds in Sriharikota Island, where flocks of 10 to 30 birds were recorded on a few occasions (Manakadan and Sivakumar 2004a). They sighted two pairs, one with 14 ducklings and the other with a duckling in the Chinna Wagu in April 2002. The species was not recorded by Rao (1998) in Sriharikota though it was reported by the earlier BNHS survey (BNHS 1977). Senthil Murugan (pers. comm.) sighted 23 birds in Kudiri Tank in 2007. Santharam (unpublished data) recorded 20 birds at Nelapattu in October 1981.

Bar-headed Goose *Anser indicus* WM Ra

The Bar-headed Goose is a rare winter migrant to the Pulicat lake area. During this study, the species was recorded only in December 2006 and January 2007, with flocks of up to 150 birds mostly sighted in abandoned crop fields near Moolah village, adjacent to Pulicat lake. Rao (1998) and Manakadan and Sivakumar (2004a) had only one sighting each of about a dozen birds flying over Sriharikota. Santharam's (unpublished data) counts include 200 birds from the Pulincherry area in January 1998 and 150 birds in Venadu Island in December 2000.

Ruddy Shelduck *Tadorna ferruginea* WM VRa

Krishnan (1990) cites the occurrence of the Ruddy Shelduck in the Pulicat area without providing details. The only records of the Ruddy Shelduck after that are of six birds sighted by us in the Kudiri tank in January 2001 and a record of three birds in Nelapattu during the 2001 Asian Waterfowl Count (AWC). Santharam (unpublished data) recorded it thrice (2-5 birds) along the Sriharikota-Sullurpet road from 1981 to 2000.

Comb Duck *Sarkidiornis melanotos* Locally Extinct?

The Comb Duck was recorded only during the first BNHS survey (BNHS 1977), but details of the sightings were not provided. Perennou (1990) had expressed alarm at the low counts obtained during the AWC in India, commenting that it is almost absent in southern India and extinct in Sri Lanka. It appears to have become extinct in the Pulicat area.

Cotton Teal ***Nettapus coromandelianus*** R VRa

The Cotton Teal was not recorded during this study. The first BNHS survey recorded 'small flocks' in the Pedda and Chinna Wagus of Sriharikota (BNHS 1977). Manakadan and Sivakumar (2004a) sighted two birds in August 2002 at the Mudugu Gunta. Rao (1998) had three sightings during his 3-year study. Santharam (unpublished data) recorded 100+ birds at a freshwater body near Tada in October 1981.

Gadwall ***Anas strepera*** WM Ra

The Gadwall was reported in small numbers in freshwater bodies of Sriharikota Island (Rao 1998; Manakadan and Sivakumar 2004a). The species is listed by Krishnan (1990), but details of the sightings are not provided. Santharam (unpublished data) sighted 20+ birds in Sriharikota Island in January 1990.

Eurasian Wigeon ***Anas penelope*** WM Ra

The Eurasian Wigeon is a relatively uncommon wintering duck frequenting only the freshwater wetlands. About 50-60 birds were occasionally recorded in Kudiri Tank, with high counts of 322 birds recorded during March 2006. Rao (1998) and Manakadan and Sivakumar (2004a) occasionally recorded the species in small numbers in the freshwater streams in Sriharikota. Santharam (unpublished data) found the species to be relatively common in the Pulicat lake area, reporting counts of more than 2,000 birds in December 1997 and January 1988. Additionally, he feels that extremely large flocks of unidentified ducks seen on three occasions from a considerable distance numbering around 37,000 (January 1998), 28,500 (January 1991) and 46,540 (January 1998), primarily consisted of this species and the Northern Pintail considering the size.

Indian Spot-billed Duck ***Anas poecilorhyncha*** R VC

The Indian Spot-billed Duck was largely recorded in freshwater wetlands around Pulicat lake and to a much lesser extent, in areas of the Pulicat lake that had submerged vegetation. About 500 birds were seen in the Kudiri Tank during April 2007. The species is common in Sriharikota Island, with flocks of around 250 birds recorded each summer in Urugayya lake (Rao 1998; Manakadan and Sivakumar 2004a). Breeding records were obtained from Sriharikota Island and the Attakanitippa and Kudiri tanks.

Northern Shoveller ***Anas clypeata*** WM C

The Northern Shoveller was recorded in Kudiri Tank and to a lesser extent Pulicat lake. The largest count recorded was *c.* 1,700 birds near the Venadu mudflats in January 2007. Rao (1998) described the species as 'a very common migratory duck recorded at all water bodies in the island'.

Northern Pintail ***Anas acuta*** WM VC

The Northern Pintail is the most common and abundant migratory duck in Pulicat lake and the adjoining wetlands. The largest count during this study was *c.* 3,300 birds. Samant and Rao (1996) had recorded a flock of nearly 4,000 birds. Around 500 birds were recorded by Manakadan and Sivakumar (2004a), and the 1991 AWC recorded *c.* 12,500 birds (Rao and Mohapatra 1993a). Santharam's (unpublished data) counts ranged from 2,000+ (December 1997) to 4,300 birds (January 1998), but see also Eurasian Wigeon.

Garganey ***Anas querquedula*** WM C

The Garganey was recorded in freshwater tanks during winter but was rarely seen in Pulicat lake. The highest counts during the AWC were 436 and 320 birds in 2003 for Pulicat and Nelapattu respectively. Rao (1998) had recorded up to 175 birds in water bodies of Sriharikota Island. Santharam (unpublished data) recorded 2,000+ birds in Pulicat lake along the Sullurpet-Sriharikota road in December 1997.

Common Teal ***Anas crecca*** WM C

The Common Teal was largely recorded in the freshwater wetlands, with a high count of *c.* 4,000 birds during the study. Rao (1998) had a count of more than 750 birds in Sriharikota in January 1991.

Common Pochard ***Aythya ferina*** WM VRa

The occurrence of the Common Pochard in Pulicat lake area is cited by Krishnan (1990) and Rao and Mohapatra (1993a) without providing details. Philip *et al.* (1998) obtained a count of 44 birds in Nelapattu. Santharam (unpublished data) recorded two birds at Nelapattu in March 1998 and found the species to be common in freshwater bodies in Nellore district. We had no sightings of the species since December 2000 while working under different projects.

Red-crested Pochard ***Rhodonessa rufina*** WM VRa

The Red-crested Pochard was recorded in small parties (<100 birds) only during January and February of 2006, and 2007 in the Kudiri Tank. The species had not been reported by earlier workers except Santharam (unpublished data), who recorded 80 birds in January 1988 and 500+ birds in January 2005 in Kudiri Tank.

Tufted Pochard ***Aythya fuligula*** WM VRa

Philip *et al.* (1998) obtained a count of 112 birds in Nelapattu. Santharam (unpublished data) recorded 140 birds

in the Tada area of Pulicat Lake in January 1998. The 2003 AWC reports a count of 230 birds. We have had no sightings of the species from December 2000 while working under various projects but found it to be common in the wetlands of Gudur, *c.* 50 km north of Pulicat.

Brahminy Kite *Haliastur indus* R C

Rao (1998) and Manakadan and Sivakumar (2004a) frequently recorded the Brahminy Kite in almost all the areas of the Sriharikota Island and occasionally in Pulicat. During this study, the species was recorded only in the southern part of the Pulicat near fishing hamlets. Santharam (unpublished data) used to record the species nesting regularly at Nelapattu and feels it is on the decline in the Pulicat area.

White-bellied Sea-Eagle *Haliaeetus leucogaster* R C

The White-bellied Sea-Eagle is fairly common in Sriharikota Island, with half a dozen nests reported (Rao 1998; Manakadan and Sivakumar 2004a). The species was frequently seen in and around Pulicat and Kudiri Tank during this study.

Western Marsh-Harrier *Circus aeruginosus* WM O

Rao (1998) reported the Western Marsh-Harrier to be common in most of the wetland areas in Sriharikota. The species was not recorded by Manakadan and Sivakumar (2004a) in Sriharikota, but they had a sighting of two birds in the northern part of Kudiri Tank. We recorded the species regularly in the freshwater wetlands of Kudiri, Mallam and Nelapattu.

Osprey *Pandion haliaetus* WM Ra

Rao (1998) recorded the Osprey occasionally in some of the large waterbodies in Sriharikota and stated it to be fairly common in Pulicat lagoon during winter. Manakadan and Sivakumar (2004a) recorded only a pair in Pulicat Lagoon off the Beripeta area of Sriharikota Island. Only a single bird was sometimes recorded from the Annamalaicherry area of Pulicat during this study. Santharam (unpublished data) had seen one or two birds along the Sriharikota road in 1990, but did not record the species subsequently.

Slaty-breasted Rail *Rallus striatus* R? VRa

The only earlier records of the Slaty-breasted Rail in the Pulicat area were made during the first BNHS survey in Sriharikota Island (BNHS 1977) and by Rao (1998) from 'marshes near Sullurpet', probably referring to the Kudiri Tank. Recently, B. Senthil Murugan and J. Patrick David (pers. comm. in 2007) obtained a road kill in Sriharikota.

Ruddy-breasted Crake *Porzana fusca* R/SM? VRa

The only record of the Ruddy Crake is by Santharam (unpublished data), who sighted a bird in January 1990 on the Sriharikota Island.

European Water Rail *Rallus aquaticus* V VRa

Manakadan and Sivakumar (2004a, 2004b) sighted a bird towards the end of May 2003 along the Pedda Wagu in Sriharikota Island. This sighting is the southernmost record of the species in India, which till then had not been reported south of Mumbai (Punjabi 1997).

White-breasted Waterhen *Amaurornis phoenicurus* R VC

The White-breasted Waterhen is a common resident species and was frequently recorded in and around freshwater habitats. Rao (1998) described it as common and seen in most well watered areas of Sriharikota Island.

Purple Swamphen *Porphyrio porphyrio* R/SM? Ra

The Purple Swamphen was recorded in freshwater tanks and largely in Kudiri Tank with about 10-15 birds recorded yearly from January to March. Rao and Mohapatra (1993a) list the species without providing details. The species was ringed in Kudiri lake in February 1989 (Balachandran 1998).

Common Moorhen *Gallinula chloropus* R VC

The Common Moorhen was recorded in Kudiri and the other freshwater tanks. The highest count of 10 birds was from the Kudiri Tank in January 2006. The species is common and breeds in Sriharikota (Rao 1998; Manakadan and Sivakumar 2004a), Nelapattu (Philip *et al.* 1998) and Vedurupattu-Edhirpattu (Santharam 1998).

Eurasian Coot *Fulica atra* R/SM? Ra

The Eurasian Coot was recorded only in freshwater tanks, and the highest count was of *c.* 250 birds in Kudiri Tank in February 2006. Rao (1998) recorded it occasionally from some of the freshwater bodies in Sriharikota Island and recorded *c.* 400 birds in May 1990 in Kudiri Tank. Philip *et al.* (1998) recorded 42 adults and 36 chicks in Nelapattu, and Santharam (1998) recorded breeding in the Vedurupattu-Edhirpattu area.

Pheasant-tailed Jacana *Hydrophasianus chirurgus* SM? O

The Pheasant-tailed Jacana was recorded in vegetated freshwater tanks just after the monsoon and till March. The highest count was 15 birds in Kudiri during March 2006. Rao and Mohaptara (1993a) sighted the species mostly in shallow freshwater bodies in Sriharikota Island with a count of 11 birds in February 1992. Manakadan and Sivakumar

(2004a) described the species as an occasional seasonal migrant in small numbers to Sriharikota. Santharam (unpublished data) sighted four birds in non-breeding plumage at Nelapattu in March 1998.

Greater Painted-Snipe *Rostratula benghalensis* WM O

The Greater Painted-Snipe was not recorded during the study, but B. Senthil Murugan and J. Patrick David (pers. comm. in 2007) obtained a sighting of a solitary bird in Kudiri Tank during the winter of 2007. The species was sighted on a few occasions around water bodies in Sriharikota in winter (Rao 1998; Manakadan and Sivakumar 2004a; Santharam, unpublished data).

Pacific Golden-Plover *Pluvialis fulva* WM C

The Pacific Golden-Plover is a regular winter migrant to Pulicat. The high counts include 239 birds in April 2005 in the Venadu mudflats and 341 birds in December 2006 at the grassy edges of Kudiri Tank. Rao (1998) cites it as very common in the coastal sand dunes in the north-eastern part of Sriharikota, mentioning flocks of 10 to 15 birds. Santharam (unpublished data) recorded 1,500 birds in January 1998.

Grey Plover *Pluvialis squatarola* WM O

The Grey Plover was rarely recorded in Pulicat lake with a few sightings of solitary birds or a party of a few birds from September till March. Rao (1998) described it as a widespread and common winter visitor to Sriharikota Island preferring coastal mudflats, reporting 12 birds in partial breeding plumage in May 1991. Manakadan and Sivakumar (2004a) recorded the species occasionally in the brackish Urugayya lake (Sriharikota Island) and Pulicat.

Common Ringed Plover *Charadrius hiaticula* WM VRa

The Common Ringed Plover was not recorded during the study and by Manakadan and Sivakumar (2004a). Rao and Mohapatra (1993a) obtained several sightings from Pulicat lake during the 1990-1991 season, stating the species was rare but adding that these was a likelihood of it being mistaken for the Little Ringed Plover. The species has been reported from the Adyar Estuary in Chennai, *c.* 40 km from Pulicat (Santharam 1989).

Little Ringed Plover *Charadrius dubius* R/SM VC

The Little Ringed Plover is a breeding resident, occurring in Pulicat lake and other open wetlands in the area. It was recorded almost throughout the year during this study. Tribals say that the species breeds in the dry bed of Katankayya lake (Sriharikota Island) during summer (Manakadan and Sivakumar 2004a). The highest count of a congregation was of *c.* 800 birds in 2007.

Kentish Plover *Charadrius alexandrinus* R/SM O

The Kentish Plover was recorded in small numbers or in pairs almost throughout the year in Pulicat lake and in other suitable freshwater and brackish water habitats. The highest count was *c.* 400 birds in Pulicat. It was suspected to breed in Pulicat lake (Samant and Rao 1996; Rao 1998; Manakadan and Sivakumar 2004a), and confirmed breeding records were obtained during this study. Breeding records of this predominantly winter migrant have been reported from the Great Vedaranyam Swamp, Tamil Nadu (Sugathan 1982; Manakadan 1992; Natarajan 1992).

Lesser Sand Plover *Charadrius mongolus* WM O/Ra

Most of the sightings of the Lesser Sand Plover were from the southern areas of Pulicat in the Annamalaichery tidal flats, with counts of up to 1,000 birds. It was not common in the central and northern parts of Pulicat. Rao (1998) found it to be not as common as the Kentish Plover, recording only small flocks of 20-30 birds. Manakadan and Sivakumar (2004a) had only one sighting of nine birds in Urugayya lake (Sriharikota) in October 2002.

Greater Sand Plover *Charadrius leschenaultii* WM VRa

The Greater Sand Plover was not sighted during the study. Mohapatra and Rao (1994) reported of a record from Pulicat lake. Rao (1998) reported a possible sighting in March 1991 from the Chandrasikuppam area of Sriharikota Island, and Manakadan and Sivakumar (2004a) recorded 14 birds in August 2002 from the same area.

Black-fronted Plover *Charadrius melanops* V VRa

The only record of the species in Pulicat Lake (and in the Indian subcontinent) is provided by T.C. Jerdon from June 1839/1840 (Ali and Ripley 1987), but the identity of the species requires further substantiation (Rasmussen and Anderton 2005).

Red-wattled Lapwing *Vanellus indicus* R C

The Red-wattled Lapwing is a common species in freshwater habitats, mostly occurring in pairs and breeding during April and May.

Pintail Snipe *Gallinago stenura* WM O

The only records of the Pintail Snipe are by Rao (1998), consisting of a few sight records and banding of a bird in Sriharikota.

Common Snipe *Gallinago gallinago* WM O

We recorded the Common Snipe occasionally in grassy areas under *Prosopis* bushes along the Pernadu road and in

agricultural fields adjacent to freshwater wetlands. Sightings were more during November and December just after the monsoon. The species is listed by Rao and Mohapatra (1993a) without providing details.

Jack Snipe *Lymnocryptes minimus* WM VRa

The occurrence of the Jack Snipe in the Pulicat lake area is reported by Rao and Mohapatra (1993a) without providing details.

Black-tailed Godwit *Limosa limosa* WM C

The Black-tailed Godwit was a regular winter migrant to Pulicat lake and Kudiri Tank. Large flocks of *c.* 1,000-2,000 birds were seen during October and January each year near the Venadu mudflats, Kudiri Tank and adjoining paddy fields. Rao (1998) described it as 'a regular but uncommon winter visitor'.

Whimbrel *Numenius phaeopus* WM Ra

The Whimbrel was occasionally seen singly or in twos or threes near Tada and in grasslands bordering the southern part of Pulicat lake. Rao (1998) and Manakadan and Sivakumar (2004a) recorded it occasionally in Sriharikota Island.

Eurasian Curlew *Numenius arquata* WM O

The Eurasian Curlew was occasionally sighted in Pulicat lake and in the Kudiri Tank usually occurring in small parties of twos and threes. An extremely high count of 154 birds was sighted in the Annamalaicherry mudflats during January 2007. Manakadan and Sivakumar (2004a) recorded it occasionally during winter in suitable habitats in Sriharikota Island. High counts by Santharam (unpublished data) are 50+ birds in Kudiri Tank in February 1990 and 70+ birds in Pulicat lake in January 2005.

Spotted Redshank *Tringa erythropus* WM Ra

The Spotted Redshank was only recorded during the second BNHS project (Rao 1998) consisting of ringing and sight records of single birds in December 1989 and April 1990. Manakadan and Sivakumar (2004a) did not record it during the winter of 2001-2002, but recorded up to 200 birds regularly during the 2002-2003 season in Pulicat lake. Only a few birds were recorded during the following winter. During April and May 2005, we recorded *c.* 60 birds in the Kudiri Tank and the Moolah Cheruvu area of Pulicat. Santharam (unpublished data) recorded the species on two occasions: one bird in April 1990 and 12 birds in January 2005.

Common Redshank *Tringa totanus* WM VC

The Common Redshank is one of the commonest sandpipers in Pulicat lake, usually occurring in small flocks. However, large congregations of almost 1,000 birds were recorded sometimes in the Annamalicherry mudflats. The species was also recorded in the Kudiri and Nelapattu tanks. It was also regularly recorded by earlier workers (BNHS 1977; Rao 1998; Manakadan and Sivakumar 2004a).

Marsh Sandpiper *Tringa stagnatilis* WM C

The Marsh Sandpiper was recorded occasionally (usually after showers) in compact flocks of a few hundred birds, and the highest count was *c.* 1,600 birds recorded during January 2007 in Pulicat. The species was also recorded in Kudiri and Nelapattu. It was also regularly recorded by earlier workers (BNHS 1977; Rao 1998; Manakadan and Sivakumar 2004a).

Common Greenshank *Tringa nebularia* WM VC

The Common Greenshank is a common winter migrant to Pulicat, usually occurring in ones or twos. Some birds over-summer in Pulicat. Earlier studies too found the species to be a common but not an abundant wintering migrant (BNHS 1977; Rao 1998; Manakadan and Sivakumar 2004a). The maximum count obtained during this study was 68 birds in April 2006.

Green Sandpiper *Tringa ochropus* WM Ra/VRa

The Green Sandpiper is a rare winter migrant. The only record during the study was outside the study area – in a drying freshwater tank near Gumudipoondi in June 2006. Earlier studies too found the species to be uncommon (BNHS 1977; Rao 1998; Manakadan and Sivakumar 2004a). Santharam (unpublished data) recorded two birds in October 1981 in Nelapattu.

Wood Sandpiper *Tringa glareola* WM C

The Wood Sandpiper was rare in Pulicat but was a common species in freshwater wetlands, occurring in small parties. It was also seen in ploughed water-logged sites adjacent to Pulicat lake. Earlier studies too found the species to be uncommon in Pulicat (BNHS 1977; Rao 1998; Manakadan and Sivakumar 2004a).

Terek Sandpiper *Xenus cinereus* WM VRa

The Terek Sandpiper was sighted only once by us in April 2000 along the Sullurpet-Sriharikota road during an earlier project. The only other record of the species in Pulicat lake was a banding record in April 1991 (Rao 1998).

Common Sandpiper *Actitis hypoleucos* WM VC

The Common Sandpiper was common in Pulicat lake

and the adjacent water bodies, occurring at the edges solitarily. It was also regularly recorded in winter by earlier workers (BNHS 1977; Rao 1998; Manakadan and Sivakumar 2004a).

Ruddy Turnstone *Arenaria interpres* WM VRa

The Ruddy Turnstone is a rare winter migrant. Two birds were recorded during May 2005 in the Annamalacherry mudflats. Manakadan and Sivakumar (2004a) sighted a bird in Urugayya lake (Sriharikota) in October 2002. It could be more common along the coast as it is primarily a dweller of sandy or rocky shores (Ali and Ripley 1987).

Great Knot *Calidris tenuirostris* WM VRa

The record of the Great Knot is based on the banding of six birds from 1990 to 1992 in Sriharikota Island (Mohapatra and Rao 1992; Rao and Mohapatra 1994; Rao 1998).

Red Knot *Calidris canutus* WM VRa

The record of the Red Knot is based only on banding records from 1990 to 1992 in Sriharikota Island (Mohapatra and Rao 1993; Rao and Mohapatra 1994; Rao 1998).

Little Stint *Calidris minuta* WM VC

The Little Stint is the most abundant wader in Pulicat lake; numbering around 20,000+ birds each year. Large flocks were usually recorded in January or February as the northern areas of Pulicat lake dry up and the birds get concentrated along the Sullurpet-Sriharikota stretch of Pulicat, moving southwards towards the lagoon edges as this stretch also gradually dries up. Santharam (unpublished data) recorded huge flocks of 30,000 birds in February 1990 and 16,000 birds in January 1991 probably of this species.

Long-toed Stint *Calidris subminuta* WM VRa

The only record of the Long-toed Stint is from Santharam (unpublished data), who sighted a bird in Kudiri Tank in December 1997.

Temminck's Stint *Calidris temminckii* WM O

Temminck's Stint was uncommon in Pulicat lake during this study, with relatively more sightings from Kudiri Tank and the Sunnambukulam area of Pulicat. Sightings were more common during 2000-2003 during an earlier BNHS project, when a few hundred birds were sometimes recorded in Kudiri Tank.

Curlew Sandpiper *Calidris ferruginea* WM Ra

The Curlew Sandpiper was rarely recorded during the study. The largest congregation recorded was about 200 birds in the Annamalaicherry tidal flats in May 2007. The species was not recorded during the first BNHS project (BNHS 1977), and Manakadan and Sivakumar (2004a) obtained only two sightings of solitary birds in Pulicat during August and September 2002. However, Rao (1998) reported it to be fairly common in Pulicat between September and mid March and recorded a bird with a Polish ring that was banded in the Arctic Circle region (Rao and Mohapatra 1993a).

Dunlin *Calidris alpina* WM VRa

Rao and Mohapatra (1993a) list the Dunlin without providing details.

Ruff *Philomachus pugnax* WM C

The Ruff is one of the most common waders of Pulicat. It was also regularly sighted in Kudiri Tank. Rao (1998) reported it to be uncommon in Sriharikota, but we recorded flocks frequently in Pulicat lake, with the highest count *c.* 1,900 birds in January 2007.

Black-winged Stilt *Himantopus himantopus* WM C

The Black-winged Stilt was a common and regular winter migrant occurring in flocks of a few hundred birds in Pulicat and other wetlands. Around 500 birds were sighted in November 2007 in Kudiri Tank. Santharam (unpublished data) counted 800 birds in January 1998.

Pied Avocet *Recurvirostra avosetta* WM VRa

The Pied Avocet was rarely recorded during the study. In June 2006, a flock of *c.* 15,000 birds was recorded in Pulicat lake. Rao (1998) recorded a flock of *c.* 500 birds during the 1989-1990 winter season. Manakadan and Sivakumar (2004a) had only one sighting of a small flock in Pulicat lake during their 3-year study. Santharam (unpublished data) recorded the species on five occasions in Pulicat lake, with flocks ranging from 200 to 845 birds.

Red-necked Phalarope *Phalaropus lobatus* WM VRa

The Red-necked Phalarope was recorded only twice during the study in the Sullurpet-Sriharikota mudflats in September 2005 and 2006. The other reports of the species were of a bird in Urugayya lake of Sriharikota in October 2002 Manakadan and Sivakumar (2004a) and banding of six birds in September 1990 (Rao and Mohapatra 1994).

Small Pratincole *Glareola lactea* SM? Ra

The only record of the Small Pratincole from the Pulicat area is of three birds sighted at Vedurupattu-Ethirpattu in January 1991 by Santharam (unpublished data).

Oriental Pratincole *Glareola maldiivarum* SM? Ra

Past records of the Oriental Pratincole include banding records by Rao and Mohapatra (1992) from Kudiri Tank, and sightings (Santharam, unpublished data) of birds in Nelapattu: two birds in August 1996 and one bird in August 1997. We recorded the species on a few occasions at the margins of Kudiri Tank: the records include 128 birds in August 2005 and 28 birds in June 2007.

Heuglin's Gull *Larus heuglini* WM VRa

The Heuglin's Gull (earlier treated as the Lesser Blackbacked Gull *Larus.fuscus*) was only recorded during the first BNHS survey of Sriharikota Island (BNHS 1977).

Great Black-headed Gull *Larus ichthyaetus* WM VRa

The Great Black-headed Gull was recorded yearly from January to March in Pulicat lake, but mostly from the northern and southern parts. The maximum count was 114 birds, recorded during March 2006. Rao (1998) and Manakadan and Sivakumar (2004a) recorded the species in small numbers in the Kudiri Tank. Santharam (unpublished data) sighted the species twice, with counts of 20+ (January 2005) and 30+ birds (January 2003)

Brown-headed Gull *Larus brunnicephalus* WM C

The Brown-headed Gull is the most common gull wintering in Pulicat lake. The highest count was of 669 birds during the study. Rao (1998) reported flocks of more than 150 birds and Santharam (unpublished data) includes a count of 550 birds.

Common Black-headed Gull *Larus ridibundus* WM?

The Common Black-headed Gull was described as very common during winter in Pulicat (BNHS 1977; Rao 1998). However, it was not recorded from 2002 to 2004 by Manakadan and Sivakumar (2004a), during this study, or by Santharam during his visits spread over 27 years. We suspect that these records were actually of juvenile Brown-headed Gulls (*see* Discussion).

Gull-billed Tern *Gelochelidon nilotica* WM VC

The Gull-billed Tern is a common winter migrant to Pulicat, foraging mostly solitarily or in twos or threes. A resting flock of *c.* 250 birds was seen near the Venadu mudflats in January 2007.

Caspian Tern *Sterna caspia* WM C

The Caspian Tern is a common tern in the lagoon areas of Pulicat and was recorded almost throughout the year. It was not recorded in freshwater wetlands, except for resting birds in Koridi Tank. About 300 resting birds were seen near the Venadu mudflats in December 2006.

Common Tern *Sterna hirundo* WM VRa

The Common Tern, largely a coastal species (Ali and Ripley 1987), was reported to be less common than other terns during the 1989-1990 season in Pulicat and there are records of the banding of seven birds (Rao and Mohapatra 1993a, 1994; Mohapatra and Rao 1994). The species was not recorded during this study and by Manakadan and Sivakumar (2004a).

Little Tern *Sterna albifrons* R/SM? Ra

The Little Tern was recorded only in freshwater tanks during winter, mostly in Kudiri Tank. The maximum number counted was 100-150 resting birds in January 2005. Samant and Rao (1996), Rao (1998), and Manakadan and Sivakumar (2004a) recorded small flocks of 15-20 birds occasionally in Pulicat lake.

Black-bellied Tern *Sterna acuticauda* V VRa

We obtained only two records of the Black-bellied Tern in the Pulicat lake area with records of single birds near Annamalaicherry in December 2006 and July 2007. The species has not been reported by earlier workers.

Whiskered Tern *Chlidonias hybridus* WM VC

The Whiskered Tern is the most common tern in Pulicat lake and in the freshwater wetlands. A flock of *c.* 300 resting birds was recorded in December 2006 in the northern part of the Pulicat. Rao (1998) and Manakadan and Sivakumar (2004a) found it to be common and widespread, recording birds also during the non-migratory season. Santharam (unpublished data) recorded a flock of 1,490 birds flying down the river at Vedurupattu-Ethirpattu (going to roost?) in February 1998.

White-winged Tern *Chlidonias leucopterus* WM VRa

The only record of the White-winged Tern is by Santharam (unpublished data), who sighted a bird in Pulicat lake in August 1996.

Black Tern *Chlidonias niger* WM VRa

The only earlier record of the Black Tern in Pulicat was based on a bird banded in Sriharikota in October 1990, the record being the first for the species in Andhra Pradesh (Rao and Mohapatra 1993c, 1994). A possible sighting of a single bird was obtained during this study in Kudiri Tank in January 2001.

Brown Fish-Owl *Ketupa zeylonensis* R Ra

The only records of the Brown Fish-Owl in Pulicat area are by Manakadan and Sivakumar (2004a), who sighted birds at two sites in Sriharikota.

Common Kingfisher *Alcedo atthis* R O

Sightings of the Common Kingfisher were rare at Pulicat lake. It was more frequently sighted around freshwater wetlands. The species is common in Sriharikota (Rao 1998; Manakadan and Sivakumar 2004a).

White-throated Kingfisher *Halcyon smyrnensis* R C

The White-throated Kingfisher is a common species in the area and was recorded in a variety of habitats even away from water sources.

Black-capped Kingfisher *Halcyon pileata* R/SM? Ra

The Black-capped Kingfisher was not recorded in Pulicat lake during the study. Manakadan and Sivakumar (2004a) recorded the species along the Buckingham Canal on two occasions and a bird at the brackish water Urugayya lake on Sriharikota in January 2002. Rao (1998) termed it as 'a winter migrant to the island affecting mangrove habitat'.

Lesser-Pied Kingfisher *Ceryle rudis* R O

The Lesser-Pied Kingfisher was occasionally recorded, throughout the year in Pulicat lake and most of the other wetlands, especially around jetties and canals. A nest was seen near Tada. The species was also recorded by earlier workers (BNHS 1977; Rao 1998; Manakadan and Sivakumar 2004a).

Other than the above discussed species, three species of wetland dependent wagtails Yellow Wagtail *Motacilla flava*, Grey Wagtail *Motacilla citreola* and White-browed Wagtail *Motacilla maderaspatensis* were recorded in the Pulicat lake area, mostly occurring at the margins of freshwater waterbodies, but details of these sightings were not maintained as for other waterbird species. Of these, the Yellow Wagtail and the Grey Wagtail are winter migrants; and the White-browed Wagtail is a resident species. The Yellow-wattled Lapwing *Vanellus malabaricus* and the Indian Stone-Curlew *Burhinus oedicnemus* also occur in the area, but we have not included these species – though generally listed in waterfowl count exercises – as these rarely occur around wetlands (Ali and Ripley 1987; Rasmussen and Anderton 2005).

DISCUSSION

Waterbirds of Pulicat Lake

Pulicat primarily serves as the foraging ground for brackish water-preferring bird species comprising residents, seasonal migrants and winter migrants from the Palaearctic region. Within Pulicat, an important foraging ground for waterbirds is the shallow region in the central part of the Lake between Sriharikota and Kudiri, which is the area mostly visited by birders due to easy accessibility (Fig. 1). This area is primarily important during November to January/early February after which it gets flooded during the North-east monsoon rains, and especially during the drying stages when it attracts large numbers of piscivorous birds (especially around the many culverts along the Sullurpet-Sriharikota road) and wader species, including flamingos. Another important site is the Moolah Kuppam area on the western edge of Pernadu Island, especially after the Kudiri-Sriharikota stretch dries up. This is a site where the Greater Flamingo may be seen almost throughout the year as borne out by this and the earlier study by Manakadan and Sivakumar (2004a). Yet another important area is Annamalaicherry at the southern end. Though part of the lagoon habitat, which is generally 'bird poor', Annamalaicherry supports high species richness and abundance of waterbirds due to a mix of micro-habitats created by various factors, and this is another site in Pulicat where the Greater Flamingo can be seen almost throughout the year. All these three areas need to be given special focus during the AWC to obtain better estimates of the bird population of Pulicat lake.

The northern areas of Pulicat are poor in bird diversity and only support populations in low densities during the North-east monsoon season, as they are shallow and remain dry for most of the summer. The southern lagoon part is deep and unattractive to most bird species, except for the margins and especially where uneven margins create micro-habitats attractive to birds as in the Annamalaicherry area. However, birds have to necessarily move to the lagoon areas as the northern and central areas of Pulicat lake dry up. The lagoon areas are also more attractive to duck species due to the abundance of aquatic vegetation, which the central and northern areas lack due to frequent drying and higher salinity.

As for the populations of waterbird species of Pulicat, it is difficult to arrive at estimates due to the vastness of the area, the difficult logistics involved in reaching most areas and the movements of birds primarily influenced by changing water regimes. AWC counts of the Pulicat lake area have ranged from a high of 83,806 in 1988 to lows of *c.* 10,000 in 1991 and 1992, but from our experience, we feel that most of these differences are more due to chance and the effort and areas covered rather than annual variations in populations. Most of the AWC exercises were along the Sriharikota-Sullurpet stretch of Pulicat lake due to the easy accessibility and bird concentrations during that period. Even here, counts

of waterbirds can vary considerably within a 2-week period depending on water levels, with the maximum number of birds expected when the drying stage creates a mosaic of shallow water, exposed flats and drying pools, with high concentrations of prey trapped in the shallows and the mudflats. Future waterfowl counts need to cover the Moolah Kuppam and Annamalaicherry areas to obtain better estimates of the bird populations of Pulicat.

Six species of Vulnerable or Near-Threatened species (classification of BirdLife International (2001) occur in the Pulicat area. Of these, the Oriental Darter and the Black-bellied Tern are rare in the Pulicat area. The Lesser Flamingo is rare compared to the Great Flamingo in Pulicat Lake, but a high count of 3,000 birds was recorded in May 2007, which is more than 1% of the biogeographic population of this species (1,500 birds; Islam and Rahmani 2004), which makes Pulicat an important wintering site for this species. The populations of the Spot-billed Pelican (Vulnerable), Black-headed Ibis (Near-Threatened) and the Painted Stork (Near-Threatened), all of which breed in the heronries in the area, also significantly surpass their estimated 1% biogeographic population of 40, 100 and 100 birds, respectively. For these reasons alone, the Pulicat lake area easily qualifies for the status of a Ramsar Site.

There appear to have been some changes over the years in the population of some waterbird species in the Pulicat area, judging from the findings obtained by earlier workers and our study. However, definite conclusions cannot be arrived at, taking into account the areas covered and the time frame of these studies. Some of the very obvious changes are with regard to the Indian Reef-Heron and Osprey. Samant and Rao (1996) mentioned that 'up to five individuals' of the Indian Reef-Egret were recorded at a time in Pulicat lake. There was only a sighting of a bird during this project in the northern part of Pulicat; the species was not recorded by Manakadan and Sivakumar (2004a) during their 3-year study. However, Samant and Rao (1996) reported it to be fairly common in Pulicat lake from September to mid-March. The Osprey was reported to be common by Samant and Rao (1996), but only a pair was occasionally sighted from one site of Pulicat lake by Manakadan and Sivakumar (2004a) and only one bird was recorded on rare occasions during this study.

As for suspected and probable wrong cases of identification, there appears to be a confusion in separating the Indian Shag from the Little Cormorant. Perusing a list of birds handed over to the Nelapattu Forest Department by a birdwatchers group during the 2001-2002 breeding season, we found that all the nesting cormorants had been identified as the Little Cormorant, while except for half a dozen nests of this species that year, all the other 200-odd nests were those of the Indian Shag. Perennou (1990) had also expressed doubts about confusion in identification between the Indian Shag and the Little Cormorant in India resulting in undercounts for the former in the AWC while considering his count of *c.* 1,200 Indian Shag in Nelapattu during the 1987-1988 breeding season. However, there also appear to be fluctuations in the nesting numbers of these two species as Philip *et al.* (1998) had counts of <3,000 Little Cormorant and only four Indian Shag in 1998, and during this study, the number of breeding Indian Shags was just a little less than that of Little Cormorant, in contrast to the earlier discussed 2001-2002 observation.

We are of the opinion that juveniles of the Brown-headed Gull (which do not have wing mirrors unlike adults) have got wrongly identified as the Common Black-headed Gull in Pulicat (and also in the Great Vedaranyam Swamp, Tamil Nadu) by earlier workers. The Common Black-headed Gull was described as very common during winters in Pulicat lake (BNHS 1977; Samant and Rao 1996) but was not recorded by Manakadan and Sivakumar (2004a), and also during this project. Ali and Ripley (1987) report the species to be more common on the western seaboard of peninsular India and also mention that published sight records are not free from ambiguity with the similar looking Brown-headed Gull. The second author, who worked in the Great Vedaranyam Swamp (GVS) for about 4 years during the 1980s, recorded the smaller Common Black-headed Gull only once as a large flock during the return migration period (Manakadan 1991), though it is reported to be a common species in some publications (Ali and Hussain 1981, 1982; Sugathan 1982). The species was also not reported by Natarajan (1992).

The Intermediate Egret was not recorded in Pulicat during this study, but a few birds were occasionally recorded in freshwater tanks. Manakadan and Sivakumar (2004a) too recorded the species only in freshwater habitats in Sriharikota but not in Pulicat. Samant and Rao (1996) state its distribution in Sriharikota Island to be 'rather uncommon in most waterbodies but often seen in good numbers towards February-March when individuals shift to the island from Pulicat'. It appears that in areas where there is an abundance of freshwater habitats, the Intermediate Egret will stick exclusively to such sites. The second author, who worked in the GVS for about four years during the 1980s, did not record the species there (Manakadan 1991), while earlier publications cite its occurrence (Ali and Hussain 1981, 1982; Sugathan 1982). All the birds recorded during the breeding season in the GVS were found to have plumes only on the back as in Great Egret (*vs.* back and breast in case of Intermediate Egret – *see* Ali and Ripley 1987).

Another likely case of wrong identification is the reported sighting of Pallas's Sea-Eagle *Haliaeetus leucoryphus* during the 2004 AWC. We suspect this to be a misidentification of an immature White-bellied Sea-Eagle, which has a plumage similar to that of an adult Pallas's Sea-Eagle as we had also made the same assumption once. The confirmed southernmost record for the species is Chilika Lake, Orissa (Ali and Ripley 1987).

Waterbirds of Adjoining Wetlands

Species partial to freshwater habits are distributed over a number of freshwater habitats on the mainland and in the islands in Pulicat including Sriharikota. Among these, Kudiri Tank at the outskirts of Sullurpet is a very important wetland for waterbirds. The tank becomes especially attractive for waterbirds when Pulicat lake starts to dry up over large tracts towards the end of early February. The lake gets more or less filled by an assortment of birds till the migrants leave for their breeding grounds towards the end of March and the tank dries up in May/June. The wetlands in Sriharikota have become an important habitat, especially for freshwater bird species and also serve as a breeding site for waterfowl species after the island was taken over by ISRO as it is now almost free of human disturbance.

Realising the importance of the southern Kudiri Tank for the Spot-billed Pelican and other waterbird species during an earlier project, Manakadan and Kannan (2003) had recommended that the tank be taken over by the Forest Department and a part of it be developed as a breeding site for heronry species on the lines of Nelapattu. It is almost certain that birds will start breeding at this site once it is developed, judging from the new heronries that have got established in Sriharikota Island. We again recommend that the tank be taken over by the Forest Department (or the SDSC-SHAR). Kudiri Tank could also turn out to be a very important tourist attraction in the Pulicat area due to its easy accessibility as it is at the outskirts of Sullurpet and on the road to Sriharikota. Suggested conservation and development measures are:

1. Fencing of the tank to demarcate the boundary of the lake and protect it from encroachments.
2. Creating mounds in the tank planted with suitable nesting trees species (e.g., *Acacia nilotica* and *Barringtonia acutangula*). A few mounds should not be planted with trees so that they serve as resting and roosting sites for ducks, terns, pelicans, etc.
3. Deepening of the eastern and southern part of the tank, and adoption of a strategy for releasing water up to the tank's current capacity, and not the extra water obtained due to deepening, so as not to create conflicts with locals for irrigation needs. The soil excavated for deepening the tank could be used for creating the mounds suggested under (2). As this tank is currently not of importance to fisheries unlike the deeper northern Kudiri Tank, conflicts with fishermen will not be a major issue. The western and northern part of the tank should not be deepened, and they may provide a habitat for shallow water-preferring bird species.

Heronries

The Pulicat lake area was known to have only three heronries till the end of the last century, all on the mainland, of which Nelapattu is the largest and most well known. Three more heronries were discovered during the beginning of this century in Sriharikota by Manakadan and Sivakumar (2004a). The six heronries in the Pulicat area support/supported 13 species of colonial waterbirds, namely, Little Cormorant, Indian Shag, Spot-billed Pelican, Little Egret, Grey Heron, Great Egret, Intermediate Egret, Eastern Cattle Egret, Black-crowned Night-Heron, Painted Stork, Asian Openbill, Black-headed Ibis and Eurasian Spoonbill. Given below is an account of the heronries in the Pulicat area.

Nelapattu

Eight heronry species were recorded breeding in Nelapattu during the study period: Little Cormorant, Indian Shag, Spot-billed Pelican, Little Egret, Eastern Cattle Egret, Black-crowned Night-Heron, Asian Openbill and Black-headed Ibis. The Eurasian Spoonbill was not recorded to breed at Nelapattu during this study and during our earlier studies (since 2000) though a few birds arrived each year during the breeding season. As for past breeding records of the species, Santharam (unpublished data) recorded it nesting in small numbers at Nelapattu in the early 1980s, and Ramakrishna (1990) had reported three or four nests in Vedurupattu-Edhirpattu. More than 500 pairs of Spot-billed Pelican were recorded breeding during the 2005-2006 and 2006-07 breeding seasons, these numbers being much higher than those recorded during 2004-2005 and during an earlier 3-year project (Manakadan and Kannan 2003), when around 250 pairs nested annually.

The Nelapattu Heronry is well protected, and the Forest Department has been taking up activities for the development and conservation of the heronry. The main problem now facing Nelapattu is from tourist activity – though the birds are apparently unaffected, judging from the nesting success. The influx of tourists is extremely high (in the thousands) during the annual Flamingo Festival organised by the Tourism Department in collaboration with other governmental departments. A lot of noise and litter is

generated during the festival. Probably, the barrier of water and the densely vegetated walkway considerably reduce the disturbance by tourists. Another conservation issue that will be especially relevant in the future will be the need to have more nesting trees to accommodate the increase in nesting birds taking into account the breeding success each year. An alternative would be to develop an additional heronry, like the Kudiri Heronry suggested earlier.

Tada (Bolegalupadu)

Breeding did not take place in the Tada (Bolegalupadu) Heronry during the 2004-05 breeding season, but took place during the 2005-2006 and 2006-2007 seasons, with five pairs of Grey Heron breeding each year. Around the same number of herons along with about 25 pairs of Little Cormorant were recorded breeding in the heronry during 2002 by us. The future of the heronry is bleak, with only one of the three nesting trees remaining and even this tree facing pressures from the houses that have come up, right under it. The new heronries in Sriharikota are probably constituted by birds that have abandoned the Tada and Vedurupattu-Edirpattu heronries – see below.

Vedurupattu-Edirpattu Heronry

Breeding did not take place in the Vedurupattu-Edirpattu Heronry during the 2004-05 and 2006-07 breeding seasons, but 20 nests of Painted Stork and 15 nests of Little Egret were recorded during the 2005-2006 breeding season. No direct threats face the Vedurupattu-Edirpattu Heronry, except that it appears that most of the birds have shifted to the new heronries in Sriharikota Island, probably due to better nesting and foraging conditions available in the Sriharikota area. The Vedurupattu-Edirpattu Heronry had earlier supported around 200 breeding pairs of Painted Stork (see species account). As for earlier breeding records of other species, Perennou and Santharam (1990) had recorded 92 nests of the Little Cormorant, 13 nests of the Grey Heron and 20 nests of the Little Egret. A few cases of nesting of the Spot-billed Pelican were also reported (Ramakrishna 1990; Santharam1998). Considering these above mentioned factors and since the future of village based heronries is more prone to risks compared to those in protected areas (Manakadan and Kannan 2003), we do not offer recommendations for the conservation of this heronry.

Sriharikota Heronries

Information on the discovery of the three heronries in Sriharikota Island (Madugu, Beripeta and Karimanal) and their breeding birds and site conditions have already been published elsewhere (Sivakumar and Manakadan 2005). Together, these heronries were recorded to have around 300 nests of the Little Cormorant, 150 nests of the Little Egret, 6 nests of the Great Egret, 1 nest of the Intermediate Egret, 18 nests of the Grey Heron, and 200+ nests of the Painted Stork. The Beripeta Heronry is now the major heronry for the Painted Stork, which in all likelihood comprises of birds that used to breed in the Vedurupattu-Edirpattu Heronry. The three heronries in Sriharikota are relatively well protected and face little human related pressures, especially for the past few years, as Sriharikota is a high-security zone and the authorities of the SDSC-SHAR being keen to conserve and develop the heronries. SDSC-SHAR is developing the Beripeta Heronry on the lines of Nelapattu (on our recommendations) and such positive developments could also be expected to take place for the other two heronries in future.

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BIRDS OF THE UPPER NILGIRIS PLATEAU, WESTERN GHATS, INDIA[1]

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Although excellent bird collections have been amassed from the Nilgiris in southern India and several bird surveys have been conducted since the late 19th century, they were either focused on the lower elevations, species specific or not intensive. Bird surveys and community investigations in the higher elevations of the Nilgiris are few, with results generally unpublished, or described only in travelogues. In the course of this first systematic effort to study the bird community structure and ecology of this region, several rare and significant birds were recorded and their status evaluated. We present here an annotated checklist of 192 bird species, of which 145 were recorded by us between December 2000 and April 2004, and 47 are records of other workers from the Upper Nilgiris Plateau (1,700 m above msl). The species list also includes ten Threatened birds: five recorded during this study and five recorded by other workers in the past. The checklist also includes seven Near Threatened species, including four recorded during this study and three by other workers. A review of the literature indicates a drastic decline in the populations of wintering snipes, Eurasian Woodcock *Scolopax rusticola* and some raptors, and the disappearance of four vulture species. Threatened species and Western Ghats endemics, such as the Black-chinned Laughingthrush *Trochalopteron cachinnans* and the White-bellied Blue Robin *Myiomela albiventris*, and the winter visitor Kashmir Flycatcher *Ficedula subrubra* were identified to be at risk on account of habitat loss and anthropogenic pressures. We discuss the conservation problems for the avifauna of the Upper Nilgiris Plateau.

Key words: Upper Nilgiris, Western Ghats, Endemic bird species, Threatened birds, Shola, Mukurthi National Park

INTRODUCTION

Since the 19th century many bird collections have been carried out on the birds of the Nilgiri Hills of the Western Ghats in India. Most of these bird surveys were either focused on the lower elevations or were not intensive with their records generally remaining unpublished or being described in travelogues on exploratory visits. Bird community investigations in the higher elevations of the Nilgiris are scarce. Davison (1883) gave perhaps the earliest and the most comprehensive account of the birds of the Nilgiris, based on his personal observations and bird collections. Cardew (1885) provided accounts of some species unrecorded or considered doubtful by Davison (1883). Baker and Inglis (1930) included natural history records on several Nilgiri birds from early 20th century, while Betts (1931) recorded observations on the behaviour and status of bulbuls, and other birds of the Nilgiris. The ecological problems of the Nilgiris were discussed by Navarro (1966), and Ali (1977) highlighted the affinities of the Nilgiri and Himalayan fauna, including the laughingthrushes.

Ornithological explorations in the Upper Nilgiris during recent decades have focused on either a single species or a group. For example, Khan (1979) studied the ecology of the Black-and-Orange Flycatcher *Ficedula nigrorufa*. Islam (1985) studied the ecology and behaviour of the Black-chinned Laughingthrush *Trochalopteron cachinnans*. Thirumurthi and Balaji (1999) surveyed raptors in Nilgiris, while Vijayan *et al.* (2000) conducted a preliminary status survey of the Black-chinned Laughingthrush. Autecology works have been carried out on a few species including the Black-chinned Laughingthrush by Zarri (2005).

The present study was the first intensive investigation of the composition and status of the birds of the Upper Nilgiris Plateau. This paper describes a total of 192 species for the Upper Nilgiris, including the species reported by earlier authors. During the course of this study nine Western Ghats endemics and several threatened species were recorded. A review of literature suggests a decline in the populations of several birds and the disappearance of some species.

STUDY AREA

Upper Nilgiris Plateau

The area covered in this paper is part of the Nilgiri Hills from 1,700 m above msl to the summit of Dodabetta (2,634 m above msl) and is commonly known as the Upper Nilgiris Plateau and lies between 11° 10' to 10° 30' N and 76° 25' to 77° 00' E (Fig. 1). Kerala bounds the Nilgiri Hills on the west, Karnataka on the north and Coimbatore district on the south-east. Eight Important Bird Areas (IBAs) have

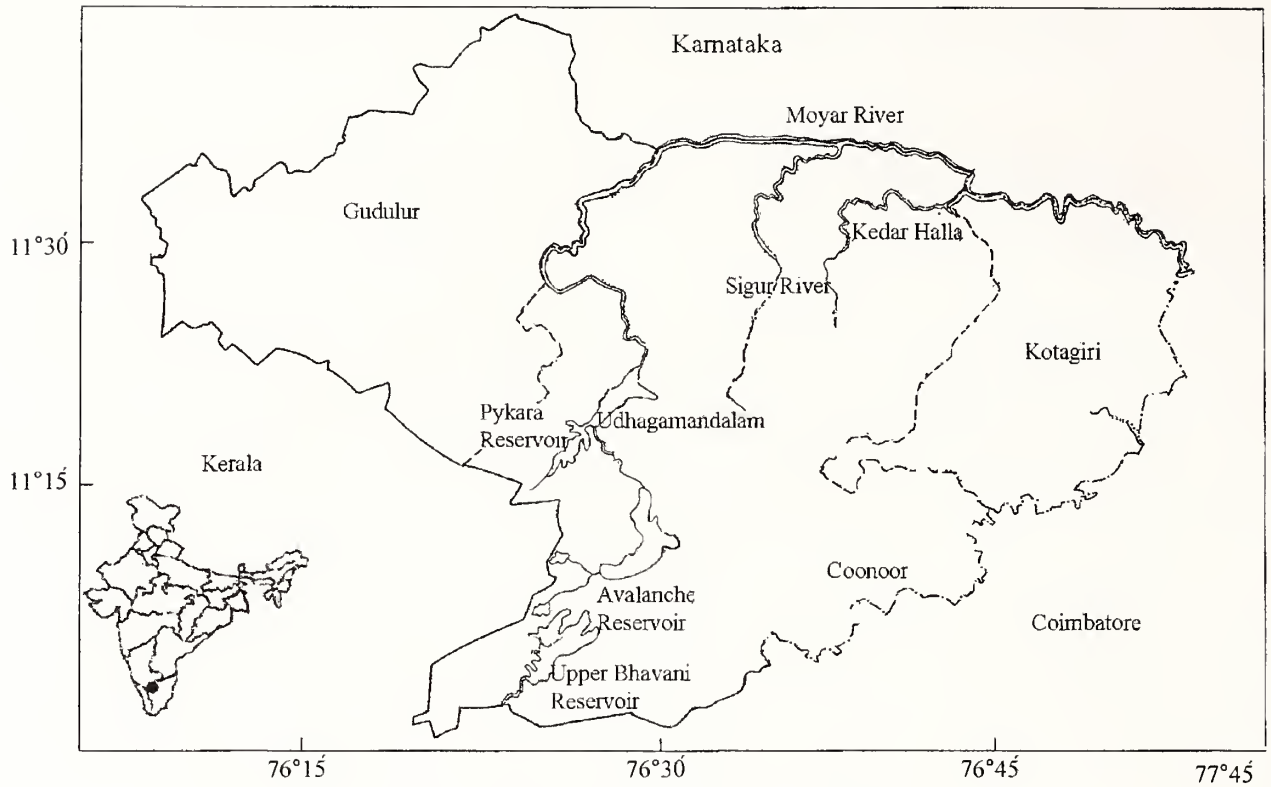

Fig. 1: Location of the Nilgiri hills, Western Ghats, India

been identified recently from the Nilgiris (Islam and Rahmani 2004).

The Nilgiris is a part of the Nilgiri Biosphere Reserve and occupies the highest and westernmost part of Tamil Nadu State. The Nilgiris is located in the Western Ghats (Zone-5) as per the biogeographic classification of India (Rodgers and Panwar 1988). The Upper Nilgiris Plateau rises sharply from the surrounding country and is divided by a range of peaks running in a general north-south direction, the highest point being Dodabetta (2,634 m above msl), which is also the second highest peak in the Western Ghats after Anaimudi (2,695 m above msl). The western end of the Plateau is sheer rock, while the interior of the Plateau consists mainly of undulating grassy hills divided by narrow valleys, each one containing a stream or swamp surrounded by shola thickets. The Upper Nilgiris Plateau forms the main watershed for two important tributaries (Bhavani and Moyar) of the Cauvery river. There are numerous streams, draining either into the Moyar, which flows eastward through a deep gully along the northern border of the district or into the Bhavani that flows on the southern border. The area receives both the Southwest and Northeast monsoons, during which the western Upper Nilgiris Plateau towards Mukurti National Park (MNP) and its surroundings receives up to 5,600 mm rainfall per year (Lengerue 1977).

Mukurti National Park

The Mukurti National Park (MNP) is the only protected area falling under our intensive study area and lies within 11° 10'-11° 22' N and 76° 26'-76° 34' E. It forms a key protected area for conservation of high altitude grassland flora and fauna. MNP encompasses an area of 78.46 sq. km, and the entire terrain is undulating grassland with patches of montane evergreen forest (shola) confined to the folds of hills and depressions. The average altitude is around 2,400 m above msl. There are several peaks, the highest being Kolari Betta 2,630 m above msl. Mukurti was declared a wildlife sanctuary in 1980 under the Wildlife (Protection) Act of 1972 and a national park in 1990, mainly for the protection of the endangered Nilgiri Tahr *Hemitragus hylocrius*.

Vegetation types in the Upper Nilgiris

The vegetation of the Upper Nilgiris can be broadly classified into Southern Montane Wet Forest (shola), grasslands and exotic plantations. Most of the forested area in the Nilgiris is under plantation, with very few natural shola patches. The Southern Montane Wet Forest type is classified as 11 A (Type C1/SD2) by Champion and Seth (1968) and is found above 1,700 m elevation and comprises short to medium size evergreen trees of both tropical and temperate origin (Shetty and Vivekananthan 1971). Such forest patches occur, as a rule at the heads of streams and in the folds of converging

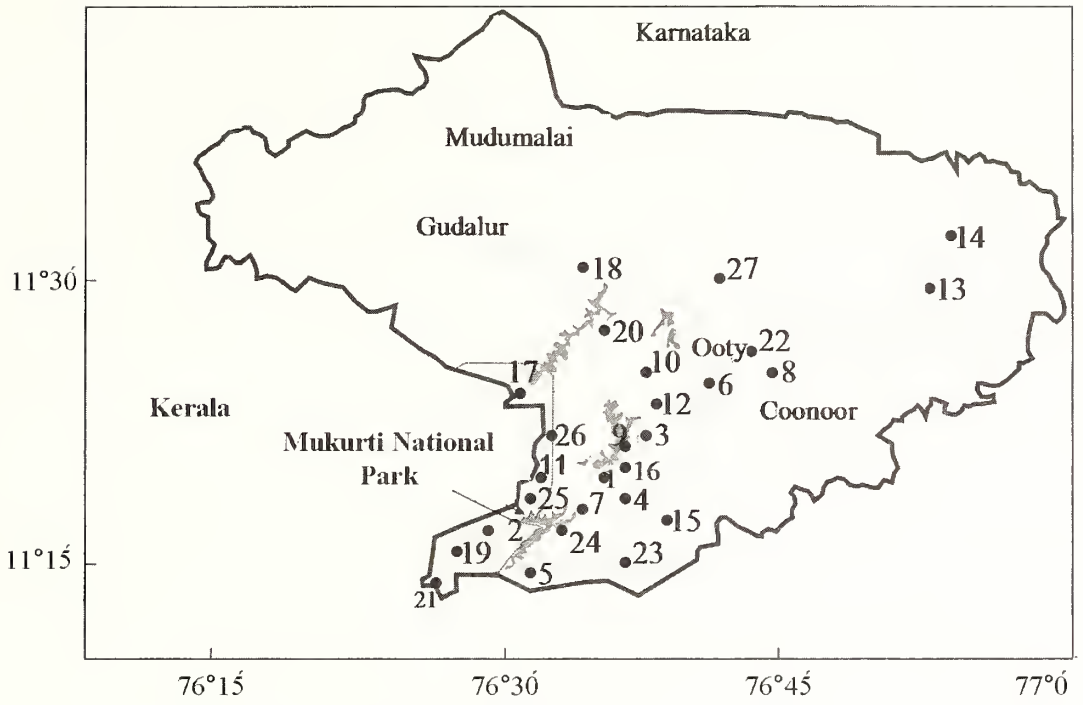

Fig. 2: The Nilgiris with localities described in the text
(1) Avalanche; (2) Bangitappal; (3) Bembatti; (4) Bikkatti; (5) Bison Swamp; (6) Cairn Hill; (7) Devar Betta; (8) Dodabetta; (9) Emerald; (10) Governor Shola; (11) Kolari Betta; (12) Ittalar; (13) Kotagiri; (14) Kodanadu; (15) Kundha; (16) Lawrence; (17) Mukurti Peak; (18) Naduvattam; (19) Nadukani; (20) Parson's Valley; (21) Sispara; (22) Snowdon; (23) Taishola Tea Estate; (24) Upper Bhavani; (25) Western Catchment II; (26) Western Catchment III; (27) Solur

species. In general, montane grasslands are located in high altitude areas of the Western Ghats. Once found on the entire Upper Nilgiris Plateau, such grasslands are presently confined to MNP with only a few good patches seen in Upper Bhavani, Lakkedi, Bison Swamp and other places. After clear felling of natural forest and burning of grasslands plantations of several exotic species were raised to feed the timber and pulp wood industry. Plantations consists of mainly Wattle *Acacia* spp., Blue Gum *Eucalyptus* spp., Pine *Pinus* spp., Cypress *Cupressus macrocarpa*, Cinchona *Cinchona cinchona*, and Tea *Thea sinensis*.

METHODS

This paper is based on the notes from our field diaries maintained during fieldwork for bird community investigations as well as observations made during extensive surveys by AAZ and BS in the study area above 1,700 m elevation between December 2000 and April 2004. MNP, Avalanche, Lakkedi, Devar Betta, Upper Bhavani and Taishola of Nilgiris South Division formed the intensive study area. Other areas surveyed during this study include Governor's Shola, Cairn Hill Forest, Snowdon, Porthimund, Dodabetta, Taishola, Kora Kundha, Coonoor, Bikkatti, Bembatti, Longwood Shola at Kotagiri, Kodanadu and Emerald Valley (Fig. 2 and Appendix 1)

Elevations in feet for the localities described in the historical records were converted to metres for uniformity in presentation. The nomenclature for the localities follows the Survey of India 1:50,000 toposheets and coordinates were recorded using a GARMIN 12XL GPS. Sites surveyed and described in this paper and their geographical locations mentioned in the paper are listed in Appendix 1.

Species recorded more than 10 times are described as common in this paper, while those seen between 3 and 10 times are described as uncommon and those seen only once or twice are termed rare for the Upper Nilgiris Plateau. The sequence followed Inskipp *et al.* (1996) while the nomenclature was followed according to Rasmussen and Anderton (2005). The conservation status of the threatened birds follows BirdLife International (2001). The status of species as recorded during this study is recorded as 'present status', while species recorded by other authors are given in a separate column. We discuss briefly the key conservation issues that are threatening the avifauna and biodiversity of the Upper Nilgiris. Our checklist includes breeding residents, winter visitors, local summer migrants, vagrants and passage migrants (Appendix 2).

The observations published in the form of an annotated checklist by Zarri *et al.* (2005) in Buceros *10(1)* included observations by the authors and did not include synthesis of available literature as summarized in the current paper. The current format of the paper would also be easy to understand and user friendly.

RESULTS

A total of 192 species was recorded from the Upper Nilgiris Plateau (till April 2004), including 47 records of earlier authors (Appendix 2). In general, the bird composition of the Upper Nilgiris appear depauperate compared to the lower elevations. For instance, Gokula (1998) recorded 265 species in the Mudumalai Wildlife Sanctuary in the lower elevations of the Nilgiri hills.

Of the 16 Western Ghats endemic species, 9 were recorded during this study, namely the Nilgiri Wood Pigeon *Columba elphinstonii*, Nilgiri Pipit *Anthus nilghiriensis*, Grey-headed Bulbul *Pycnonotus priocephalus*, Black-and-Orange Flycatcher *Ficedula nigrorufa*, Small Sunbird *Leptocoma minima*, Nilgiri Flycatcher *Eumyias albicaudatus*, Black-chinned Laughingthrush *Trochalopteron cachinnans*, White-bellied Blue Flycatcher *Cyornis pallipes* and White-bellied Blue Robin *Myiomela albiventris*. Of the remaining seven species, Indian Rufous Babbler *Turdoides subrufus* and Indian Broad-tailed Grass-Warbler *Schoenicola platyurus* might be expected towards the northern or eastern slopes of the Nilgiris, although we found no evidence of their presence during our visits.

Threatened species (BirdLife International 2001) recorded from the study area during this study include the Black-chinned Laughingthrush (Endangered) and Kashmir Flycatcher, Lesser Kestrel *Falco naumanni*, White-bellied Shortwing and Nilgiri Wood Pigeon (Vulnerable). Near Threatened species recorded during this study include the Nilgiri Pipit, Black-and-Orange Flycatcher and Nilgiri Flycatcher. Threatened species recorded from the Upper Nilgiris Plateau by other authors and not seen during this study include White-rumped Vulture *Gyps bengalensis* and Indian Vulture *Gyps indicus* (both the species are Critically Endangered); Lesser Florican *Sypheotides indicus* (Endangered) and Eastern Imperial Eagle *Aquila heliaca* and Wood Snipe *Gallinago nemoricola* (Vulnerable). Near Threatened species recorded by other authors include the Red-headed Vulture *Aegypius calvus*, Pallid Harrier *Circus macrourus*, Black-necked Stork *Ephippiorhynchus asiaticus* and Ferruginous Duck *Aythya nyroca*.

Compared to the records of Davison (1883), it appears that some species such as the Brahminy Kite *Haliastur indus*, House Crow *Corvus splendens*, Besra Sparrowhawk *Accipiter virgatus*, Crested Serpent Eagle *Spilornis cheela*, Emerald Dove *Chalcophaps indica*, Alpine Swift *Tachymarptis melba* and White-throated Kingfisher *Halcyon smyrnensis* are more common presently than during the 19th century. However, species that have recorded a noticeable decline in the Upper Nilgiris include the Pallid Harrier, White-rumped Vulture, Long-billed Vulture, Red-headed Vulture, Egyptian Vulture, Eurasian Woodcock, Wood Snipe, Pintail Snipe *Gallinago stenura*, Jacobin Cuckoo, Large Hawk-cuckoo, Common Hawk-cuckoo.

Selected species accounts

Nilgiri Wood Pigeon *Columba elphinstonii*

Vulnerable. This species is a common resident and is restricted to the shola habitat; it is found in all eight IBAs of the Upper Nilgiris (Islam and Rahmani 2004).

Lesser Florican *Sypheotides indicus*

Endangered. No recent record of this species is known from the Nilgiris. Davison (1883) quoted Hume "a specimen was killed on the slopes to the Nilgiris some years ago between Naduvattam and Pykara, going down to the Wynaad". The bird presumably might have been a vagrant, but the record should be considered of historical importance.

Eurasian Woodcock *Scolopax rusticola*

Uncommon winter visitor. Once a common winter visitor and a favourite game bird, its population has apparently declined on the Nilgiris. A single bird was observed on December 28, 2002 in a small moist and shaded grass patch beside a wattle stand in Avalanche (an IBA). Subsequently, we sighted (probably) the same bird at the earlier site on December 30, 2002, December 31, 2002, January 05, 2003, and January 22, 2003. Another bird was sighted near Kolari Betta close to a waterhole along the road on January 23, 2003. Two more birds were sighted in January 2003 at Avalanche, another in December 2003 at Avalanche and one more in January 2004 at Lakkedi.

Davison (1883) reported the Eurasian Woodcock to be common from about October to the end of February in the Nilgiris. Home and Logan (1923) mention that a Woodcock was shot in April 28 near Mukurti Peak. This is an exceptionally late date for the Woodcock at the Nilgiris. Baker reported shooting up to 6 birds in a day and 35 during the season. He shot 35 in 1920-1921, and 29 in 1921-1922 (Inglis 1923). Whistler and Kinnear (1936) summarized the records of hunting by various authors by suggesting it was a common bird on the Upper Nilgiris.

The Eurasian Woodcock is believed to be a non-stop long distance flier in India, flying from the Himalaya to the Nilgiri Hills (a distance of 2,500 km) (Sengupta 1990a). Sengupta (1990b) suggested a migratory route of the species from Himalaya to Nilgiris via Bangladesh, West Bengal [where several specimens were netted in Salt Lake, Calcutta (now Kolkata) between 1963 and 1969] and Eastern Ghats, with or without a stopover. However, Rasmussen and Anderton (2005) have shown two routes in their book (plate 58, volume1): one via Punjab-Haryana-Rajasthan and northern Western Ghats, and another via Bangladesh and Eastern Ghats, both merging in the southern Western Ghats.

Wood Snipe *Gallinago nemoricola*

Vulnerable. This winter visitor was not recorded during this study. Davison (1883) considered that it "was never common and seems to be getting still rarer, year by year". The fact that 13 birds were shot in the Nilgiris between 1922 and 1935, however, suggested that no decline had taken place and that a small wintering population survived (Whistler and Kinnear 1936). Also, from his game records between 1923 and 1948, Phythian-Adams (1948) listed only 8 birds of this species shot in the Nilgiris unlike the Pintail and Fantail snipes that figured in the thousands. Hence, we assume that this is the rarest of all snipes wintering in the Upper Nilgiris.

Egyptian Vulture *Neophron percnopterus*

We did not see even a single individual between December 2000 and April 2004. Davison (1883) reported them as abundant at the Nilgiris, especially at Ootacamund and in the vicinity of villages of *Badaga* community and on slopes, and breeding on numerous cliffs and slopes. Primrose (1904) also noted them as very common around the *Badaga* villages of the Nilgiris, and reported a large breeding colony at *Kota* community village near Kotagiri. Thirumurthi and Balaji (1999) reported the species at Coonoor (1,800 m above msl).

White-rumped Vulture *Gyps bengalensis*

Critically Endangered. Not a single bird was seen by us during this study. More than 120 years ago, Davison (1883) had recorded them as abundant in the Nilgiris. Primrose (1904) described it as the most common vulture but nowhere plentiful, at the higher elevations. In recent years, this species has been reported to have declined greatly in many other parts of India (Prakash 1999). It disappeared from the Upper Nilgiris much before the vulture decline was noticed elsewhere, the reasons being far from known. Oaks *et al.* (2004) reported the residues of the non-steroidal anti-inflammatory drug Diclofenac to be the cause of the decline of this bird and of *G. indicus* in Pakistan. Schultz *et al.* (2004) implicated the same drug for the crash in their populations in India and Nepal.

Indian Vulture *Gyps indicus*

Critically Endangered. We did not see a single bird. Davison (1883) recorded it as occurring uncommonly in the Nilgiris and its slopes, while Primrose (1904) was not certain about its presence, as he could not observe it. It declined from the Upper Nilgiris much before the vulture crisis was observed in most other places. Refer the previous account for the details of the causes of the decline of the *Gyps* vultures.

Red-headed Vulture *Aegypius calvus*

Critically Endangered. We did not find any during this study, but it was once a common vulture on the Nilgiris. Davison (1883) reported it to be not abundant and found mostly singly and sometimes in flocks of 6-50 vultures. Primrose (1904) reported it to be common and observed a nest near Craigmore Toll Gate, Ootacamund. In view of the earlier observations it appears that they have severely declined during the 20th century. Thirumurthi and Balaji (1999) claim to have recorded the species at Ootacamund and Kotagiri. Local birdwatchers (S. Sounderrajan and Ramneek Singh pers. comm., 2003) deny seeing this species in the last two to three decades.

Lesser Kestrel *Falco naumanni*

Vulnerable. Vagrant or rare passage migrant. On November 16, 2001, a single female was seen perched on a wattle tree along the road near Upper Bhavani. The bird stayed on the perch sufficiently for us to observe its whitish claws and less distinct moustachial stripes.

White-bellied Blue Robin *Myiomela albiventris*

Vulnerable. Common resident. Up to eight birds (usually single) could be seen foraging on the road passing through a shola in a vehicular drive of 200-300 m, immediately after sunset at Avalanche. It is recorded in all the eight IBAs of the Upper Nilgiris (Islam and Rahmani 2004).

Kashmir Flycatcher *Ficedula subrubra*

Vulnerable. Uncommon winter visitor sparsely distributed in the Upper Nilgiris. Three birds sighted between March 09 and 27, 2001 at Avalanche. 16 birds were recorded during an intensive survey between October 08, 2001 and April 04, 2002 in different localities, namely Avalanche, Bembatti, Ramaya Road and Emerald Valley (*see* Zarri and

Rahmani 2004 for details). Among the eight IBAs, it has been recorded only in Avalanche (Islam and Rahmani 2004).

Apparently it shows site fidelity, as three pairs were recorded coming exactly to the same small plantation patches (winter territory) in the winters of 2001 to 2003 (Zarri and Rahmani 2004). A male was ringed on January 24 and a female on January 30, 2003 at Avalanche. However, we could not locate these birds at Avalanche during the winters of 2003 and 2004. We need more ringing data to determine the extent of site fidelity in this species.

Black-and-Orange Flycatcher *Ficedula nigrorufa*

Near Threatened. Common resident, all over Nilgiris associated with the shola habitat. Ten nests with an average clutch of two eggs were recorded between February and May 2002 and 2003 in shola habitat at Avalanche, Longwood shola, Taishola, Mullimunth and Snowdon (all located 2,000 m above msl). The nest is globular and untidy with an entrance more or less at top. All the nests located during this study were lined with the blades of a sedge *Carex baccans*. Nests are generally placed on a dead stump about 1 m from the ground with a little cover. Pittie (1989) sighted a fledgling in mid-June at Sim's Park near Coonoor.

Nilgiri Flycatcher *Eumyias albicaudatus*

Near Threatened. Common resident, it affects both shola and plantations. Sixteen cup-shaped nests, generally placed in earthen banks and holes in trees, with a clutch of two or three pinkish-white eggs, were recorded during this study at Bangitappal, Avalanche, Western Catchment-III, Longwood shola, Mullimunth, Taishola, Bikkatti, Bembatti, Dodabetta and Parson's Valley. We observed them feeding on fruits on several occasions. Dewar (1904) also recorded them feeding on fruits. Nilgiri Flycatcher is found in all the eight IBAs of the Upper Nilgiris (Islam and Rahmani 2004).

Grey-headed Bulbul *Pycnonotus priocephalus*

Vagrant or rare resident in the Upper Nilgiris Plateau, only one bird sighted at Taishola on April 25, 2002. Davison (1883) found one specimen near Coonoor (1,800 m above msl). Jameson (1976) also recorded it at Coonoor. Apparently, it is more common at lower elevations and on the slopes of the Nilgiris. Therefore, the sighting of this species in the Upper Nilgiris (above 2,100 m above msl) is of interest.

Yellow-browed Bulbul *Iole indica*

Vagrant or rare resident, perhaps subject to vertical movements. One bird was seen in Taishola (2,100 m) on April 25, 2002. It is reported from places such as Kodanadu, Kotagiri and Naduvattam at lower elevations. This bird does not occur on the Plateau of the Nilgiris and is common below about 2,000 m (Davison 1883). Jameson (1976) records the species at Coonoor. It was thought to be restricted to the evergreen forests, but in recent times it has spread to deciduous forests perhaps due to the loss of its evergreen forest habitat throughout the Western Ghats.

Black-chinned Laughingthrush *Trochalopteron cachinnans*

Endangered. Common resident, it is the only bird primarily endemic to the Nilgiri hills, usually seen above 1,600 m. It is found in all the eight IBAs of the Upper Nilgiris (Islam and Rahmani 2004). It was locally common (Ali and Ripley 1987), but has now declined (BirdLife International 2001). Zarri (2005) recorded 58 nests during his 4-year study on the ecology of this bird. Most of the nests were found in shola habitat mostly along the edges, on stunted trees or shrubs between one and four metre height. All nests were located between 1,900 to 2,500 m above msl.

Nilgiri Pipit *Anthus nilghiriensis*

Near Threatened. Common resident, restricted to the undisturbed grasslands at higher elevations areas such as Bangitappal, Western Catchment and Lakkedi. It is found in good numbers at Avalanche and MNP and sparingly on other sites. Uma Maheswari (pers. comm., 2003) observed a nesting preference for larger tussock forming grasses in the valleys. However, during this study three nests were recorded in short tussocks with little cover, on ridges in MNP at 2,000 to 2,100 m.

Bird conservation issues

Habitat loss has been implicated as one of the major causes for the decline of many bird species (BirdLife International 2001). In the Nilgiris, habitat conversion and loss occurred rampantly during the 19th and 20th centuries. However, the process has been slowed down since the enactment of the Forest Conservation Act in 1980. Except for the MNP, the entire study area is unprotected, and thus faces problems of habitat degradation, plant invasions and burgeoning anthropogenic pressures due to infrastructure development. Key conservation issues are as follows.

Species decline or disappearance: A comparison of our bird records with the published literature from the last two centuries reveals a catastrophic decline or disappearance of some vultures, many raptors and snipes. Among these, the *Gyps* vulture disappearance from the study area has been the most striking one. However, the decline of the vultures from the Nilgiris started long before the catastrophic decline of the *Gyps* species in north and north-west India in the mid

1990s (Prakash 1999) due to the non-steroidal anti-inflammatory drug Diclofenac, which has been implicated as the reason for the steep decline of the *Gyps* vultures in South Asia (Oaks *et al.* 2004; Shultz *et al.* 2004).

The Eurasian Woodcock *Scolopax rusticola* and various species of snipes (Wood Snipe *Gallinago nemoricola*, Pintail Snipe *G. stenura*, Common Snipe *Gallinago gallinago* and Jack Snipe *Lymnocryptes minimus*), the popular game birds, abundant during the early 20th century (Davison 1883; Phythian-Adams 1927) have declined in the Upper Nilgiris. Apparently, hunting pressure and habitat loss during the post-independence period may have resulted in such grave declines.

Habitat loss and conversions: The native biodiversity of the Nilgiris has borne the brunt of years of unscientific forestry operations. Serious losses to the Nilgiris biodiversity occurred as the montane evergreen forests (shola) and high altitude grasslands were converted into monoculture plantations. The opening up of the hills for settling immigrant labourers of the tea, timber and pulp wood industries and other development projects led to clear felling of sholas and grasslands. Landowners started raising trees on a commercial scale to the extent that at one time wood was cheaper than the cost of cutting it (Davidar 1986). Several fast growing species, such as Australian Blackwood *Acacia melanoxylon*, Wattle *A. mearnsii*, Blue Gum *Eucalyptus globulus*, Pine *Pinus* spp., Cypress *Cupressus macrocarpa* and Tea *Thea sinensis* were introduced. Wattle regenerates through seeds and thus slowly spreads into the native grasslands.

Infrastructure development and human settlements: Davidar (1986) described the Nilgiris as an encroacher's paradise and its ecology as "grievously fractured". High precipitation in the Nilgiris invited other major threats from hydroelectric projects such as Pykara in 1932 and the giant Kundha project set up with Canadian aid in the 1960s. These projects and many others still continue despite opposition from the local NGOs. After the completion of hydroelectric projects, all the labourers settled in these hills. Several new roads were built under these projects that further opened up remote and inaccessible forests and made them more vulnerable to exploitation. The ecology of this hill complex was further damaged, particularly near Coonor and Kotagiri, with the settling of the repatriates from Sri Lanka under the Sastri-Srimavu Pact.

Agricultural intensification: Huge areas of natural habitat in the Nilgiris have been converted to agriculture, notably for vegetables. Excessive reliance on inorganic pesticides and fertilisers in the current agricultural practices in the Nilgiris lead to effects that are usually neglected. We suspect that the excessive use of inorganic fertilizers and pesticides all over the Nilgiris affects many bird species, including common birds. Inorganic pesticides have been implicated for breeding failures in many species; and we suspect that many species might be getting affected by their excessive use in the Nilgiris also.

Plant invasions and habitat loss: Avifauna specific to the grassland habitat in the study area faced major threats due to conversion of grasslands to plantations and introduction of alien invasive species. Most of these were introduced in the Nilgiris during the British period. For instance, one senior official, a Scot, is in fact reputed to have gone to the extent of filling his pockets with the seeds of the Gorse *Ulex europaeus* and scattering them about freely during his walks (Davidar 1986). Scotch broom *Cytisus scoparius* and Gorse have invaded native habitats in many countries, and in the Nilgiris there has been considerable loss of grassland habitat, affecting birds such as the Nilgiri Pipit and other biodiversity (Zarri *et al.* 2007).

Intentional grassland fires: Frequent and intentional burning of the grassland habitat poses another major threat to the endemic flora and fauna of the region. Five major fires were recorded between January-June 2003 in MNP, burning around 20-25% of the grassland area. Grassland is burnt every year by people from Kerala to lure Sambar *Cervus unicolor* with fresh grass for poaching. The burning corresponds with the breeding seasons of grassland dependent birds, such as the Nilgiri Pipit. Much to the delight of poachers, this is also the time when fires spread very fast due to the bulk accumulation of litter in the grasslands.

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Appendix 1

Checklist of birds recorded in the Upper Nilgiris Plateau, Western Ghats between December 2000 and April 2004 (Includes historical records)

Name	Present Status	Historical records	Threat Category	Notes
Painted Bush Quail *Perdicula erythrorhyncha*	R, C			
Red Spurfowl *Galloperdix spadicea*	R, C			
Grey Junglefowl *Gallus sonneratii*	R, C			
Indian Peafowl *Pavo cristatus*	M, R			One adult male sighted at Avalanche on March 10, 2001
Common Teal *Anas crecca*	W	*		Small parties seen at Ootacamund Davison (1883)
Ferruginous Duck *Aythya nyroca*	W, V/R		NT	A.C. Sounderrajan (pers. comm.) sighted a bird at Ootacamund Lake in 1995
Rufous Woodpecker *Micropterus brachyurus*	V	*		One specimen obtained near Ootacamund (Davison 1883)
White-bellied Woodpecker *Dryocopus javensis*	V/R			
Streak-throated Woodpecker *Picus xanthopygaeus*	R, C			
Black-rumped Flameback *Dinopium benghalense*	R, C			
Greater Flameback *Chrysocolaptes lucidus*	R, C			
White-cheeked Barbet *Megalaima viridis*	R, C			
Ceylon Small Barbet *Megalaima rubricapillus*	R, R			
Common Hoopoe *Upupa epops*	R, C			Davison (1883) shot great numbers in the Nilgiris; reported uncommon in Ootacamund (Stairmand 1972)
Malabar Trogon *Harpactes fasciatus*	V/RM			A pair seen at Taishola on April 25, 2002
Indian Roller *Coracias benghalensis*	R, UC			Does not ascend to the Nilgiri Plateau (Davison 1883)
Common Kingfisher *Alcedo atthis*	V/RR			One seen at Avalanche on January 11, 2003 and one on May 20, 2003; one seen by Kumar (1996) at Pykara
Stork-billed Kingfisher *Pelargopsis capensis*	R, C			
White-throated Kingfisher *Halcyon smyrnensis*	R, C			Recorded as a straggler by Davison (1883)
Black-capped Kingfisher *Halcyon pileata*	V			One recorded near Avalanche Reservoir on March 08, 2002
Little Green Bee-eater *Merops orientalis*	V/RR			One seen on June 29, 2002 at Mullimunth
Chestnut-Headed Bee-Eater *Merops leschenaulti*	R, UC			Two seen at Kundha, never seen in MNP; does not occur on Plateau (Davison 1883)
Jacobin Cuckoo *Clamator jacobinus*	RR	*		Common in Nilgiris (Davison 1883)
Large Hawk-Cuckoo *Hierococcyx sparverioides*	W	*		Numerous on the Nilgiris (Davison 1883)
Common Hawk-Cuckoo *Hierococcyx varius*		*		Plentiful in Nilgiris (Davison 1883)
Common Cuckoo *Cuculus canorus*	W, R			One bird seen at Avalanche and another at upper Bhavani on September 30, 2002
Asian Koel *Eudynamys scolopacea*	V	*		One bird collected at Ootacamund (Davison 1883)
Greater Coucal *Centropus sinensis*	R, C			
Plum-headed Parakeet *Psittacula cyanocephala*	V, R			One bird seen at Avalanche on August 06, 2002
Malabar Parakeet *Psittacula columboides*	R, UC			Many shot close to Ootacamund (Davison 1883)
Himalayan Swiftlet *Collocalia unicolor*	R, C			
Indian White-rumped Spinetail *Zoonavena sylvatica*	R, C			
Alpine Swift *Tachymarptis melba*	R, C			Uncommon in the Nilgiris (Davison 1883)
Common Barn Owl *Tyto alba*	V/RR			A dead one found in good condition at Ootacamund in April 2004, was skinned and sent to the BNHS collection

Appendix 1 (*contd.*)
Checklist of birds recorded in the Upper Nilgiris Plateau, Western Ghats between December 2000 and April 2004
(Includes historical records)

Name	Present Status	Historical records	Threat Category	Notes
Collared Scops Owl *Otus lettia*		*		Recorded by Primrose (1904)
Forest Eagle Owl *Bubo nipalensis*		*		Occurs sparingly on the Nilgiris (Davison 1883)
Brown Fish Owl *Ketupa zeylonensis*	R, C			
Mottled Wood Owl *Strix ocellata*	R, R			One adult sighted on August 5, at Avalanche
Brown Wood Owl *Strix leptogrammica*	R, C			
Jungle Owlet *Glaucidium radiatum*		*		Recorded as uncommon by Primrose (1904) up to 1,940 m near Terrace Tea Estate
Short-Eared Owl *Asio flammeus*	R, R			Two seen at Bangitappal, one on March 03, 2001 and another in June 2002
Grey Nightjar *Caprimulgus jotaka*	R, C			
Indian Little Nightjar *Caprimulgus asiaticus*	R, C			
Rock Pigeon *Columba livia*	R, C			
Nilgiri Wood Pigeon *Columba elphinstonii*	R, C		VU	See text
Laughing Dove *Streptopelia senegalensis*		*		Occurs sparingly in the Upper Nilgiris (Davison 1883)
Spotted Dove *Streptopelia chinensis*	R, C			
Eurasian Collared-Dove *Streptopelia decaocto*		*		One shot near Ootacamund (Davison 1883)
Emerald Dove *Chalcophaps indica*	M, C			Seen upto 2,400 m during this study; Davison (1883) did not find it as high as at Ootacamund (2,000 m)
Ceylon Green Pigeon *Treron pompadora*	V			One seen at Avalanche on September 14, 2002
Lesser Florican *Sypheotides indicus*	V	*	EN	See text
White-breasted Waterhen *Amaurornis phoenicurus*	R, C			Common around Ootacamund Lake
Common Moorhen *Gallinula chloropus*	R, C			
Eurasian Woodcock *Scolopax rusticola*	W, UC			See text
Wood Snipe *Gallinago nemoricola*	W	*	VU	See text
Pintail Snipe *Gallinago stenura*	W, R			One recorded at Avalanche on February 20, 2004
Common Snipe *Gallinago gallinago*	W	*		See (Davison 1883); Inglis (1923); Phythian-Adams (1948) for details
Jack Snipe *Lymnocryptes minimus*	W	*		Davison (1883); Phythian-Adams (1948)
Green Sandpiper *Tringa ochropus*	W, C			Recorded as rare by Davison (1883)
Wood Sandpiper *Tringa glareola*		*		Seen at Botanical Garden Ootacamund by Davison (1883)
Common Sandpiper *Actitis hypoleucos*	W, C			
Black-winged Stilt *Himantopus himantopus*	V	*		A.C. Sounderrajan (pers. comm.) sighted one bird at Ootacamund Lake in 1995
Red-wattled Lapwing *Vanellus indicus*	R, C			
Osprey *Pandion haliaetus*	W, R			One adult seen near Upper Bhavani Dam on December 19, 2003
Black-shouldered Kite *Elanus caeruleus*	R, C			
Black Kite *Milvus migrans*	R/W, C			
Brahminy Kite *Haliastur indus*	R, C			Not numerous on the Nilgiris (Davison 1883); uncommon (Primrose 1904)
Egyptian Vulture *Neophron percnopterus*		*		See text
White-rumped Vulture *Gyps bengalensis*		*	CE	See text

Appendix 1 (*contd.*)
Checklist of birds recorded in the Upper Nilgiris Plateau, Western Ghats between December 2000 and April 2004
(Includes historical records)

Name	Present Status	Historical records	Threat Category	Notes
Indian Vulture *Gyps indicus*		*	CE	See text
Red-headed Vulture *Sarcogyps calvus*		*	NT	See text
Short-toed Eagle *Circaetus gallicus*	W	*		One seen at Taishola on June 22, 2002; one seen again at Taishola on July 04, 2002
Crested Serpent Eagle *Spilornis cheela*	R, C			Davison (1883) recorded them as absent on the Nilgiri Plateau
Black Eagle *Ictinaetus malayensis*	R, W			
Eurasian Marsh Harrier *Circus aeruginosus*		*		Common on the Nilgiris (Davison 1883)
Pied Harrier *Circus melanoleucos*				Occurs sparingly (Davison 1883)
Pallid Harrier *Circus macrourus*		*	NT	Recorded as abundant (Davison 1883); six birds seen (Thirumurthi and Balaji 1999)
Crested Goshawk *Accipiter trivirgatus*		*		Seven birds in four locations (Thirumurthi and Balaji 1999); no other records known from the Upper Nilgiris
Shikra *Accipiter badius*	R, UC			Recorded as common (Davison 1883); a sighting at Solur described as unusual (Kumar 1992)
Besra Sparrowhawk *Accipiter virgatus*	R, C			Described as rare by Davison (1883)
Eurasian Sparrowhawk *Accipiter nisus*		*		One female shot on February 07, 1881 (Davison 1883); 16 birds seen near Kotagiri and Kilkotagiri (Thirumurthi and Balaji 1999)
Oriental Honey-buzzard *Pernis ptilorhyncus*	W, C			
White-eyed Buzzard *Butastur teesa*	W, UC			
Steppe Buzzard *Buteo buteo vulpinus*	W, C			
Long-legged Buzzard *Buteo rufinus*	W, C			
Eastern Imperial Eagle *Aquila heliaca*		*	VU	Recorded as an occasional visitor (Burgess 1937)
Bonelli's Eagle *Hieraaetus fasciatus*	R, UC			Three birds seen at Taishola on September 12, 2003. Reported as common by Burgess (1937)
Booted Eagle *Hieraaetus pennatus*		*		Noted as common (Primrose 1904)
Rufous-bellied Eagle *Hieraaetus kienerii*		*		Four birds recorded during a raptor survey (Thirumurthi and Balaji 1999)
Changeable Hawk Eagle *Spizaetus limnaeetus*		*		Certainly occurs (Davison 1883); one bird seen (Stairmand 1972)
Mountain Hawk Eagle *Spizaetus nipalensis*	V	*		One specimen given to Davison by Mr. F.L. Chapman of Ootacamund or Mr. Hume, the only specimen known to Davison (1883)
Lesser Kestrel *Falco naumanni*	V/PM		VU	See text
Common Kestrel *Falco tinnunculus*	R, C			
Peregrine Falcon *Falco peregrinus*		*		One pair obtained by Davison (1883); one bird seen by Thirumurthi and Balaji (1999)
Little Grebe *Tachybaptus ruficollis*	R, C			
Oriental Darter *Anhinga melanogaster*		*		Obtained at Pykara (9 miles from Ootacamund) by Davison (1883)
Great Cormorant *Phalacrocorax carbo*	R, C			
Little Egret *Egretta garzetta*	R			One seen on January 11, 2004 and another on January 16, 2004, both at Avalanche reservoir. One seen at T.R. Bazar (S. Thejaswi, pers. comm.)

Appendix 1 (*contd.*)
Checklist of birds recorded in the Upper Nilgiris Plateau, Western Ghats between December 2000 and April 2004
(Includes historical records)

Name	Present Status	Historical records	Threat Category	Notes
Eastern Cattle Egret *Bubulcus coramandus*	R, C			
Indian Pond Heron *Ardeola grayii*	R, C			Seen year-round in contrast to the observations of Davison (1883).
Black-crowned Night Heron *Nycticorax nycticorax*	R, R			One seen at Bangitappal on March 08, 2002
Malayan Night-heron *Gorsachius melanolophus*	V			One sub-adult sighted near Parson's Valley on May 21, 2003
White Stork *Ciconia ciconia*	V	*		Eighteen birds seen at Sandy nullah (between Ootacamund and Pykara) (Davison 1883)
Black-necked Stork *Ephippiorhynchus asiaticus*	V	*	NT	A.C. Sounderrajan (pers. comm.) sighted one bird at Cairn Hill in 1990 and Photographed
Indian Pitta *Pitta brachyuran*	W, UC			
Brown Shrike *Lanius cristatus*	W, C			
Long-tailed Shrike *Lanius schach*	R, C			
House Crow *Corvus splendens*	R, C			Does not ascend hills of the Nilgiris (Davison 1883)
Large-billed Crow *Corvus (macrorhynchos) culminatus*	R, C			
Ashy Woodswallow *Artamus fuscus*	R, R			One seen near Kotagiri on January 13, 2002
Eurasian Golden Oriole *Oriolus oriolus*	W, UC			
Black-hooded Oriole *Oriolus xanthornus*		*		Shot on several occasion close to Ootacamund (Davison 1883)
Black-headed Cuckooshrike *Coracina melonoptera*		*		Shot at Botanical Garden, Ootacamund (Davison 1883); reported from Coonoor (Jameson 1971)
Scarlet Minivet *Pericrocotus speciosus*	V			Only one male observed on March 29, 2003 at Avalanche
Pied Flycatcher-Shrike *Hemipus picatus*	R, C			
White-throated Fantail *Rhipidura albicollis*	R, C			
White-browed Fantail *Rhipidura aureola*	R, C			
Ashy Drongo *Dicrurus leucophaeus*	W, C			
Bronzed Drongo *Dicrurus aeneus*		*		Seen as well as shot by Davison (1883)
Greater Racket-tailed Drongo *Dicrurus paradiseus*	V	*		Only one specimen shot by Davison (1883), on the Ootacamund-Kotagiri road (Davison 1883)
Asian Paradise-flycatcher *Terpsiphone paradisi*	M, C			
Common Iora *Aegithina tiphia*	R, UC			
Blue-headed Rock Thrush *Monticola cinclorhynchus*	W, UC			
Malabar Whistling-Thrush *Myiophonus horsfieldii*	R, R			Never recorded at Ootacamund (Davison 1883); never seen or heard at Coonoor (Jameson 1969); one recorded near Governor's Shola (Nair 1995)
Pied Ground Thrush *Zoothera wardii*		*		Recorded mainly at lower elevations close to Coonoor (Khan 1980)
Orange-headed Thrush *Zoothera citrina*	R, UC			
Small-billed Scaly Thrush *Zoothera dauma*	R, C			
Common Blackbird *Turdus merula*	R, C			
White-bellied Shortwing *Myiomela albiventris*	R, C		VU	See text
Asian Brown Flycatcher *Muscicapa dauurica*	W, R			
Rusty-tailed Flycatcher *Muscicapa ruficauda*		*		Occurs sparingly on the Nilgiris Plateau (Davison 1883)
Brown-breasted Flycatcher *Muscicapa muttui*	W, R			

Appendix 1 (*contd.*)
Checklist of birds recorded in the Upper Nilgiris Plateau, Western Ghats between December 2000 and April 2004
(Includes historical records)

Name	Present Status	Historical records	Threat Category	Notes
Kashmir Flycatcher *Ficedula subrubra*	W, UC		VU	See text
Black-and-Orange Flycatcher *Ficedula nigrorufa*	R, C		NT	See text
Verditer Flycatcher *Eumyias thalassinus*	W, UC			Extremely rare (Davison 1883)
Nilgiri Flycatcher *Eumyias albicaudatus*	R, C		NT	See text
White-bellied Blue Flycatcher *Cyornis pallipes*	R, R			
Tickell's Blue Flycatcher *Cyornis tickelliae*		*		One specimen obtained (Davison 1883); two males seen at Ootacamund (Kumar 1996); recorded at Coonoor (Jameson 1976)
Grey-headed Canary Flycatcher *Culicicapa ceylonensis*	R, C			
Indian Blue Robin *Luscinia brunnea*	W, C			
Oriental Magpie-robin *Copsychus saularis*	R, C			
Pied Bushchat *Saxicola caprata*	R, C			
Rosy Starling *Sturnus roseus*	W, R			One sub-adult seen at Avalanche in January 2003
Common Myna *Acridotheres tristis*	R, C			Does not ascend the Nilgiris Plateau (Davison 1883); common about Coonoor (Dewar 1904)
Jungle Myna *Acridotheres fuscus*	R, C			
Velvet-fronted Nuthatch *Sitta frontalis*	R, C			
Great Tit *Parus major*	R, C			
Black-lored Yellow Tit *Parus xanthogenys*	R, UC			A total of 10 birds seen in three different sightings on different dates
Dusky Crag-martin *Ptyonoprogne concolor*	R, C			
Barn Swallow *Hirundo rustica*	W, C			
House Swallow *Hirundo tahitica*	R, C			
Red-Rumped Swallow *Hirundo daurica*	PM, R			Only one flock of about 100 birds seen on November 02, 2003 at Bangitappal
Grey-headed Bulbul *Pycnonotus priocephalus*	V/RR			See text
Red-whiskered Bulbul *Pycnonotus jocosus*	R, C			
Red-vented Bulbul *Pycnonotus cafer*	R, C			
Yellow-browed Bulbul *Iole indica*	V/RR			See text
Black Bulbul *Hypsipetes leucocephalus*	R, C			
Grey-breasted Prinia *Prinia hodgsonii*	V			
Plain Prinia *Prinia inornata*	R, C			
Ashy Prinia *Prinia socialis*	R, C			
Oriental White-eye *Zosterops palpebrosus*	R, C			
Blyth's Reed-warbler *Acrocephalus dumetorum*	W, C			
Eastern Orphean Warbler *Sylvia crassirostris*	R, C			Common towards Coonoor, never seen in MNP
Common Tailor Bird *Orthotomus sutorius*	R, UC	*		Recorded about Coonoor (Davison 1883; Pittie 1989; Dewar 1904); Never seen at Ootacamund or MNP
Tickell's Leaf Warbler *Phylloscopus affinis*	W, C			
Greenish Warbler *Phylloscopus trochiloides*	W, C			
Large-billed Leaf Warbler *Phylloscopus magnirostris*	W, C			
Tytlers's Leaf Warbler *Phylloscopus tytleri*	W	*		Two specimens obtained: one on March 10, 2001 and another on January 22, 2002 (Davison 1883)
Black-chinned Laughingthrush *Trochalopteron cachinnans*	R, C		EN	See text
Puff-Throated Babbler *Pellorneum ruficeps*	R, R			

Appendix 1 (*contd.*)
Checklist of birds recorded in the Upper Nilgiris Plateau, Western Ghats between December 2000 and April 2004
(Includes historical records)

Name	Present Status	Historical records	Threat Category	Notes
Indian Scimitar Babbler *Pomatorhinus (schisticeps) horsfieldii*	R, C			
Tawny-bellied Babbler *Dumetia hyperythera*		*		Shot at Naduvattam (1,800 m) (Davison 1883)
Large Grey Babbler *Turdoides malcolmi*		*		The only record of a single flock of 20 birds at Ootacamund (Davison 1883)
Jungle Babbler *Turdoides striata*	R, C			
Brown-cheeked Fulvetta *Alcippe poioicephala*	R, C			
Crested Lark *Galerida cristata*	R, UC			Uncommon but seen towards Kotagiri and never in MNP
Thick-billed Flowerpecker *Dicaeum agile*	R, C			
Small Sunbird *Leptocoma minima*	R, C			
Purple Sunbird *Cinnyris asiatica*	M, R			
House Sparrow *Passer domesticus*	R, C			
Forest Wagtail *Dendronanthus indicus*	W, UC			Described as rare by Davison (1883)
White-browed Wagtail *Motacilla maderaspatensis*	R, C			
Western Yellow Wagtail *Motacilla flava*	W, R			
Grey Wagtail *Motacilla cinerea*	W, C			
Richard's Pipit *Anthus richardi*	W, UC			
Paddyfield Pipit *Anthus rufulus*	R, C			
Long-billed Pipit *Anthus similis*	R, UC			
Nilgiri Pipit *Anthus nilghiriensis*	R, C		NT	See text
Olive-backed Pipit *Anthus hodgsoni*	W, C			
Red Avadavat *Amandava amandava*	R, UC			Common in Nilgiris as per Davison (1883)
Scaly-breasted Munia *Lonchura punctulata*	R, C			
Common Rosefinch *Corpodacus erythrinus*	W, C			

Sequence follows Inskipp *et al.* 1996; Nomenclature follows Birds of South Asia. The Ripley Guide. Pamela C. Rasmussen & John C. Anderton (2005)
Key: Present Status: W = wintering; R = resident; M = migrant (summer or monsoon migrant); PM = passage migrant; V = vagrant; C = common (more than ten sightings); UC = uncommon (seen between three to nine times); R = rare (one or two sightings); RR = rare resident; RM = rare migrant
* = species recorded by earlier authors but not seen by us between December 2000 and April 2004 (check for source in the Notes column).
Threat category: CE = critically endangered; EN = endangered; VU = vulnerable; NT = near threatened (follows BirdLife International (2001).
MNP = Mukurti National Park

Appendix 2

Gazetteer of localities mentioned in the text

Locality	Coordinates	Altitude (m above msl)
Avalanche*	11° 29.884' N 76° 59.163' E	2,100
Bangitappal	11° 25.880' N 76° 51.765' E	2,200
Bembatti	11° 33.358' N 76° 65.445' E	2,000
Bikkatti	11° 26.948' N 76° 62.239' E	2,050
Bison Swamp	11° 21.360' N 76° 53.020' E	2,300
Cairn Hill	11° 38.717' N 76° 67.808' E	2,100
Coonoor	11° 33.715' N 76° 79.918' E	1,800
Devar Betta	11° 25.912' N 76° 57.343' E	2,300
Dodabetta	11° 40.156' N 76° 73.738' E	2,634
Emerald	11° 31.483' N 76° 62.595' E	1,950
Governor's Shola *	11° 39.221' N 76° 64.279' E	2,100
Kolari Betta	11° 28.354' N 76° 56.518' E	2,550
Kotagiri	11° 43.287' N 76° 87.476' E	1,850
Kodanadu	11° 51.222' N 76° 40.221' E	1,700
Kundha	Not available	1,900
Lakkedi	11° 26.789' N 76° 55.497' E	2,150
Mukurti Peak*	11° 37.005' N 76° 51.893' E	2,500
Naduvattam	11° 48.641' N 76° 54.308' E	1,750
Nadukani	11° 22.579' N 76° 46.710' E	2,150
Parson's Valley	Not available	2,100
Snowdon	11° 43.115' N 76° 72.084' E	2,200
Taishola Tea Estate*	11° 21.223' N 76° 61.246' E	2,000
Ootacamund (Ooty)	11° 40.344' N 76° 69.734' E	2,000
Upper Bhavani	11° 22.256' N 76° 53.086' E	2,200
Western Catchment II*	11° 31.833' N 76° 54.483' E	2,200
Western Catchment III*	11° 33.407' N 76° 55.381' E	2,300

Localities nomenclature follows Survey of India toposheets except for *Ootacamund* (replacing Udhagamandalam and Ooty).
* = IBA or part of an IBA

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FAUNAL DIVERSITY OF CLADOCERA (CRUSTACEA: BRANCHIOPODA) OF DEEPOR BEEL, ASSAM (NORTH-EAST INDIA) – A RAMSAR SITE

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Plankton samples collected from the Deepor beel, a Ramsar site, revealed 45 species of Cladocera belonging to 30 genera and 7 families, representing the highest biodiversity of these micro-crustaceans known till date from any individual aquatic ecosystem of the Indian subcontinent. The cladoceran taxocoenosis is characterized by the predominance of Chydoridae > Daphniidae, Cosmopolitan > Cosmotropical elements, general tropical character and occurrence of several interesting species. The richness (17-41, 29 ±6; 20-41, 32 ±6 species) exhibits multimodal and trimodal monthly patterns with peaks during winter and minima during early summer, and records 53.3-93.3 and 58.6-97.5% community similarities (*vide* Sorenson's index) at two sampling stations (I and II) respectively. Our results indicate lack of seasonal periodicity of occurrence of different species or families, show dominance of facultative planktonic littoral-periphytic elements and occurrence of fewer limnetic species. The cluster analysis exhibits higher similarities in composition of Cladocera during winter and autumn, while spring and summer communities show more qualitative differences. ANOVA registers significant differences in species richness between sampling stations as well as between months. The richness registers significant inverse relationship with water temperature and rainfall, and direct correlation with transparency, dissolved oxygen and hardness; while multiple regression indicates significantly higher cumulative influence of ten abiotic factors.

Key words: Ramsar site, Deepor beel, Cladocera, faunal diversity, distribution, temporal variations

INTRODUCTION

Taxonomic studies on Indian freshwater Cladocera were initiated by Baird (1860), subsequent publications deal with their α-taxonomy based on collections from scattered localities of India (Sharma and Michael 1987; Michael and Sharma 1988; Sharma 1991). The information on ecosystem diversity of these entomostracous crustaceans in various aquatic ecosystems, in general, and in the floodplain lakes and wetlands of India, in particular, is still scanty. This generalization especially holds true for the cladoceran fauna of north-eastern India wherein the only contribution on ecosystem diversity is restricted to the rice-field environs of Meghalaya (Sharma, in press). The observations are made presently on nature and composition of the cladoceran taxocoenosis of Deepor beel, temporal variations in species richness, community similarities, occurrence and distribution of interesting elements, and on influence of abiotic factors on their richness.

STUDY AREA

The present study was undertaken from November, 2004 to October, 2005 at Deepor beel (26° 03' 26" N; 90° 36' 39" E; area: 40 sq. km; altitude: 42 m above msl) located in Kamrup district of lower Assam (NE India). This perennial floodplain wetland and a Ramsar site is covered with a luxuriant growth of diverse aquatic macrophytes, namely *Hydrilla verticellata*, *Najas indica*, *Euryale ferox*, *Vallisneria spiralis*, *Utricularia flexuosa*, *Trapa bispinosa*, *Eichhornia crassipes*, *Monochoria hastaefolia*, *Xanthium straumarium*, *Ipomea fistulosa*, *Croton borplandianum*, *Hygroryza aristata*, *Polygonum hydropiper* and *Limnophila* sp.

METHODOLOGY

Water samples collected monthly from two sampling stations (I and II) were analyzed for various abiotic factors. Water temperature, specific conductivity and pH were recorded using field probes, and transparency was noted with a Secchi disc. Dissolved oxygen was estimated using modified Winkler's method and other chemical parameters were analyzed following APHA (1992).

Qualitative plankton samples were obtained from the two sampling stations by towing a nylobolt plankton net (No. 25), and were preserved in 5% formalin. Various species and their disarticulated appendages were mounted in Polyvinyl alcohol-lectophenol mixture. The head pores and their arrangements were studied following Megard (1965). The cladoceran species were identified from Smirnov (1971, 1976, 1992, 1996), Smirnov and Timms (1983), Michael and Sharma (1988), Korovchinsky (1992), Sharma and Sharma (1999), Orlova-Bienkowskaja (2001) and Korinek (2002).

Percentage similarities between monthly cladoceran

communities were calculated *vide* Sorensen index and were analyzed by the hierarchical cluster analysis. Ecological relationships were computed *vide* simple correlation coefficients (r_1 and r_2) and multiple regression (R_1^2 and R_2^2) at stations I and II individually and significance of temporal variations was ascertained *vide* ANOVA.

SYSTEMATIC LIST OF THE EXAMINED TAXA

Super-class: Crustacea
Class: Branchiopoda
Super-order: Cladocera *s. str.*
Order: **Ctenopoda**
Family: **Sididae**

1 *Diaphanosoma excisum* Sars, 1885
2. *D. sarsi* Richard, 1895
3. *Pseudosida bidentata* Herrick, 1884
4. *Sida crystallina* (O.F. Müller, 1776)

Order: **Anomopoda**
Family: **Daphniidae**

5. *Ceriodaphnia cornuta* Sars, 1885
6. *C. reticulata* (Jurine, 1820)
7. *Scapholeberis kingi* Sars, 1903
8. *Simocephalus acutirostratus* (King, 1853)
9. *S. serrulatus* (Koch, 1841)
10. *S. vetulus* (O.F. Müller, 1776)

Family: **Bosminidae**

11. *Bosmina longirostris* (O.F. Müller, 1776)
12. *Bosminopsis deitersi* Richard, 1895

Family: **Moinidae**

13. *Moina micrura* Kurz, 1874
14. *Moinodaphnia macleayi* (King, 1853)

Family: **Macrothricidae**

15. *Macrothrix laticornis* (Fischer, 1857)
16. *M. triserialis* (Brady, 1886)
17. *Grimaldina brazzai* Richard, 1892

Family: **Ilyocryptidae**

18. *Ilyocryptus spinifer* Herrick, 1882

Family: **Chydoridae**
Subfamily: **Chydorinae**

19. *Alonella excisa* (Fischer, 1854)
20. *Chydorus faviformis* Birge, 1893
21. *C. pubescens* Sars, 1901
22. *C. sphaericus* (O.F. Müller, 1776)
23. *C. reticulatus* Daday, 1898
24. *Dadaya macrops* (Daday, 1898)
25. *Disperalona caudata* Smirnov, 1996
26. *Dunhevedia serrata* Daday, 1898
27. *Ephemeroporus barroisi* Richard, 1894
28. *Picripleuroxus similis* (Vavra, 1900)

Subfamily: **Aloninae**

29. *Acroperus harpae* (Baird, 1894)
30. *Alona affinis* (Leydig, 1860)
31. *A. intermedia* Sars, 1862
32. *Alona costata* Sars, 1862
33. *A. globulosa* (Daday, 1898)
34. *A. guttata* Sars, 1862
35. *A. quadrangularis* (O.F. Müller, 1776)
36. *A. rectangula* Sars, 1862
37. *Euryalona orientalis* (Daday, 1898)
38. *Camptocercus rectirostris* Schoedler, 1862
39. *C. uncinatus* Smirnov 1971
40. *Graptoleberis testudinaria* (Fischer, 1854)
41. *Karualona karua* (King, 1853)
42. *Kurzia longirostris* (Daday, 1898)
43. *Leydigia acanthocercoides* (Fischer, 1854)
44. *Leydigiopsis curvirostris* Sars, 1901
45. *Oxyurella singalensis* (Daday, 1898)

RESULTS AND DISCUSSION

Water samples collected from Deepor beel show low specific conductivity and are thus characterized (Table 1) by low ionic concentrations; this feature warrants the inclusion of this Ramsar site under 'Class I' category *vide* Talling and Talling (1965). Mean water temperature affirms tropical range concurrent with its geographical location. The circum-neutral and marginally hard waters of this wetland show moderate dissolved oxygen, low free CO_2 and low concentration of micro-nutrients. Chloride and BOD_5 values reflect some possible impact of human activity. In general, the ranges of abiotic factors broadly concur at the two sampling stations (I and II) and also agree with earlier results of Sharma and Hussain (1999) and Sharma (2005).

Plankton samples examined from the Deepor beel reveal 45 species of Cladocera belonging to 30 genera and 7 families; the richest biodiversity known till date from any individual floodplain lake or aquatic ecosystem of the Indian subcontinent. The cladoceran fauna is rich and diverse both in species, and genera and families. The former aspect assumes special importance in view of a conservative estimate of occurrence of up to 60-65 Cladocera species in tropical and subtropical environs of India (Sharma and Michael 1987;

Table 1: Abiotic factors of Deepor beel

Factors	Station I	Station II
Rainfall (mm)	204.5 ± 160.4	204.5 ± 160.4
Water temperature (°C)	27.2 ± 4.6	27.4 ± 5.1
pH	6.89 ± 0.18	6.93 ± 0.21
Transparency (cm)	51.9 ± 26.2	52.7 ± 25.3
Specific Conductivity (µS/cm)	99.2 ± 13.2	96.8 ± 15.5
Dissolved oxygen (mg/l)	6.7 ± 1.6	7.0 ± 1.1
Free CO_2 (mg/l)	7.2 ± 2.1	6.8 ± 1.9
Alkalinity (mg/l)	66.3 ± 12.1	68.9 ± 10.3
Hardness (mg/l)	62.1 ± 9.9	61.2 ± 12.3
Calcium (mg/l)	20.1± 2.2	22.1± 1.8
Magnesium (mg/l)	4.0 ± 0.7	4.2 ± 0.9
Chloride (mg/l)	34.6 ± 5.2	35.1 ± 5.0
Phosphate (mg/l)	0.18 ± 0.07	0.19 ± 0.10
Sulphate (mg/l)	10.2 ± 3.2	9.9 ± 3.4
Nitrate (mg/l)	0.72 ± 0.12	0.74 ± 0.14
Silicate (mg/l)	3.02 ± 1.02	3.10 ± 1.27
BOD_5 (mg/l)	3.11 ± 0059	3.21 ± 0.46
Dissolved Organic Matter (mg/l)	3.84 ± 0.80	3.90 ± 0.64
Total dissolved Solids (mg/l)	2.37 ± 0.29	2.57 ± 0.30

Sharma 1991). The present results in general reflect environmental heterogeneity and micro-habitat diversity of this important wetland of north-east India; this generalization re-affirms our earlier remarks (Sharma and Sharma 2005) based on the biodiversity of Rotifera of Deepor beel.

The Cladocera richness noticed in our observations presents a distinct contrast to the reports of only 11 species from two floodplain lakes (Khan 1987) of Kashmir; 9 species from 65 wetlands of 24-Parganas district (Nandi *et al.* 1993) of West Bengal; one species (Baruah *et al.* 1993), 4 species (Sinha *et al.* 1994) and 12 species (Sanjer and Sharma 1995) from the floodplains of Bihar; 14 species from 37 floodplain lakes (Sarma 2000) of Assam, 3 species from Mori beel (Goswami and Goswami 2001) from Assam; and 36 species from 20 wetlands from the floodplains of south-eastern West Bengal (Khan 2003). The notably lower richness in various mentioned works may be attributed to incomplete species inventories, due to lack of taxonomic expertise of several earlier workers, coupled with lack of extensive sampling of the cladoceran communities. The faunal diversity of these micro-crustaceans in Ramsar sites of India, distinctly exceeds 12 species, including certain doubtful species, recorded from Loktak (Shyamananda Singh 1991), an important floodplain lake of Manipur. The present report is also higher than the 30 species examined from 30 wetlands of Keoladeo National Park (Venkataraman 1992).

Leydigiopsis curvirostris and *Disperalona caudata* are two globally interesting species documented from Deepor beel. The former is known only from Brazil and is now reported as a new record from the Oriental region (Sharma and Sharma 2007). Further, we initially believed it to be rare and restricted to Deepor beel, but it was observed recently in our samples collected from certain beels of upper Assam and Cachar district. *D. caudata* is a new addition to the Indian subcontinent and is so far recorded only from Thailand and Australia; this chydorid is, hence, designated as an Australasian element (Sharma and Sharma *loc cit.*), and shows an interesting affinity between the Cladoceran fauna of north-eastern India, Southeast Asia and Australia. Our report of the occurrence of the two species in India may represent an example of their introduction by man and thus deserves further attention. This generalization re-affirms remarks of Dumont (1997) regarding emphasis on human introductions of several cladoceran species in different parts of the globe.

Camptocercus uncinatus is a biogeographically interesting recent addition to the Indian Cladocera (Sharma 2008); the present study represents its second record from this country. Our observations indicate possible wider distribution of this chydorid and call for the need of re-examination of all earlier reports of an allied species, *C. australis* from India and elsewhere. *Grimaldina brazzai* is yet another interesting addition to the cladoceran fauna of north-eastern India; this circumtropical member of the Macrothricidae is known so far from Rajasthan and West Bengal. In addition, twenty-four species are new records from Assam. Species such as *Ceriodaphnia reticulata*, *Chydorus faviformis*, *C. pubescens*, *C. reticulatus*, *Dadaya macrops*, *Graptoleberis testudinaria* and *Kurzia longirostris* comprise examples of a regional distributional interest.

The cladoceran fauna of Deepor beel depicts a general tropical character with a greater qualitative richness of Cosmopolitan > Cosmotropical species and presence of several Circumtropical and Pantropical species. These salient features are endorsed by the occurrence of a typical Circumtropical genera namely *Dadaya* and *Grimaldina*, the Pantropical *Ephemeroporus* and the Tropicopolitan *Moinodaphnia*; though a number of the documented genera are known for their cosmopolitan or worldwide distribution (Dumont and Negrea 2002).

The examined collections are characterized by qualitative predominance of the littoral-periphytonic species which, in turn, is attributed to shallow nature of this wetland together with the growth of several aquatic macrophytes. The notable among these are the members of the Chydoridae, Macrothricidae, Sidiidae and Ilyocryptidae. On the other hand, the cladoceran communities include fewer limnetic taxa belonging to the Daphniidae, Bosminidae and Moinidae. The sporadic occurrence of limnetic *Daphnia lumholtzi* at the two sampling stations of Deepor beel during winter season merits special interest for further investigations. Further, it may be

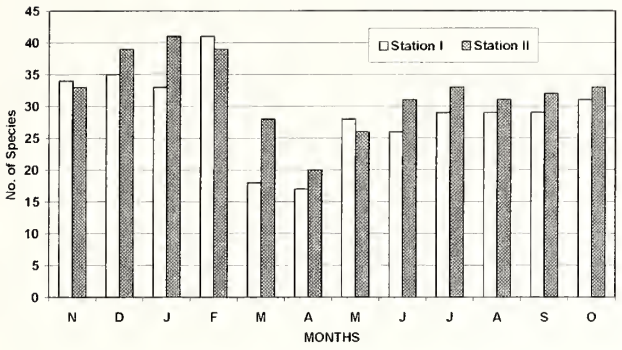

Fig. 1: Cladocera richness

noted that *D. lumholtzi* shows very restricted occurrence and distribution in aquatic environs of north-eastern India.

In general, the Cladocera contribute significantly to richness of zooplankton ($r_1 = 0.921$, $r_2 = 0.952$) and micro-crustacean ($r_1 = 0.992$, $r_2 = 0.995$) communities of the Deepor beel. The broadly comparable total number of species observed at station I (45 species) and II (43 species) may be attributed to broadly identical macrophyte associations at the sampled sites. The monthly cladoceran richness varies between 17-41 (29 ±6) and 20-41 (32 ±6) species, and exhibits (Fig. 1) multimodal and trimodal patterns of temporal variations at two sampling stations respectively. The peak richness is noticed during winter and dips are observed during summer; the present results, however, exhibit lack of seasonal periodicity of different species or families. ANOVA registers significant temporal variations in the species richness between sampling stations ($F_{1, 11} = 9.992$, $p < 0.005$) and between months ($F_{11, 11} = 11.240$, $p < 0.005$).

The Cladocera richness exhibits significant inverse correlation with water temperature ($r_1 = -0.776$, $r_2 = -0.803$) and rainfall ($r_1 = -0.768$, $r_2 = -0.720$) and direct relationship with transparency ($r_1 = 0.591$, $r_2 = 0.609$), dissolved oxygen ($r_1 = 0.782$, $r_2 = 0.683$) and hardness ($r_1 = 0.552$, $r_2 = 0.523$). Besides, it records direct correlation with specific conductivity only at station II ($r_2 = 0.622$). Multiple regression indicates notably higher cumulative influence of ten abiotic factors,

Table 2: Percentage similarities (Sorenson's index) between Cladoceran communities (Station I)

Months	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
November	-	88.8	88.2	88.0	61.5	62.7	85.2	76.7	88.9	85.7	79.4	86.1
December		-	91.4	93.3	59.2	60.4	82.5	74.2	86.1	83.1	83.1	80.6
January			-	88.0	61.5	58.8	78.7	73.0	79.4	82.5	79.4	83.1
February				-	57.6	58.6	76.5	77.6	82.9	77.1	82.0	83.3
March					-	74.3	53.3	77.3	68.1	59.6	63.8	65.3
April						-	59.1	69.8	69.6	65.2	65.2	58.3
May							-	64.1	82.1	89.3	78.6	79.3
June								-	72.7	72.7	69.1	77.2
July									-	86.2	79.3	90.0
August										-	79.3	80.0
September											-	76.7
October												-

Table 3: Percentage similarities (Sorenson's index) between Cladoceran communities (Station II)

Months	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
November	-	88.9	89.2	91.7	78.7	64.1	78.0	78.1	81.8	81.8	76.9	84.8
December		-	95.0	94.9	77.0	61.0	76.9	82.8	86.1	85.7	87.3	91.7
January			-	97.5	81.1	59.0	77.6	83.3	86.5	83.3	84.9	83.8
February				-	77.6	61.0	76.9	85.7	93.3	82.9	84.5	88.9
March					-	58.6	66.9	74.6	72.1	74.6	76.7	78.7
April						-	78.3	66.7	64.1	66.7	65.4	64.1
May							-	77.2	77.2	80.7	75.9	74.6
June								-	78.1	83.9	79.4	78.1
July									-	87.5	83.1	84.8
August										-	82.5	78.1
September											-	86.1
October												-

namely water, temperature, rainfall, pH, transparency, specific conductivity, dissolved oxygen, alkalinity, hardness, phosphate and nitrate on their monthly richness at the two sampling stations ($R_1^2 = 0.9803$, $R_2^2 = 0.9922$). The step-wise regression, however, records significance of hardness, conductivity, pH and transparency at station I and of only hardness and pH at station II.

Chydoridae, the most diverse family of Cladocera, forms a distinctly dominant qualitative component at the Deepor beel with occurrence of 27 species belonging to 17 genera and contributes significantly to the richness of these micro-crustaceans at the two sampling stations ($r_1 = 0.726$, $r_2 = 0.779$). The Chydorid richness varies between 9-24 (17±4) and 12-22 (19±3) species at the two stations respectively and registers significant temporal variations between stations ($F_{1, 11} = 7.693$, $p < 0.01$) as well as months ($F_{11, 11} = 8.705$, $p < 0.005$). Further, this family follows multimodal and trimodal patterns (Fig. 2) of monthly richness identical to that of the Cladocera and shows lack of any seasonal periodicity. The Chydoridae indicate significant inverse correlation with water temperature ($r_1 = -0.637$, $r_2 = -0.759$) and rainfall ($r_1 = -0.638$, $r_2 = -0.661$), and direct relationship with transparency ($r_1 = 0.605$, $r_2 = 0.673$), dissolved oxygen ($r_1 = 0.652$, $r_2 = 0.777$) and hardness ($r_1 = 0.548$, $r_2 = 0.609$). In addition, the Chydorids record significant direct correlation with specific conductivity ($r_2 = 0.615$) and alkalinity ($r_2 = 0.646$) only at station II.

The cladoceran communities indicate (Tables 2, 3) similarities (*vide* Sorenson's index) ranging between 53.3-93.3% (station I) and 58.6-97.5% (station II). Our results show values between >70-90% in majority of instances (65.1% and 75.8 %) included in the two similarity matrices respectively and, therefore, exhibit lesser monthly variations in their species composition. Further, the samples collected during winter (December *vs.* February at station I, January *vs.* February at station II) record peak similarities while

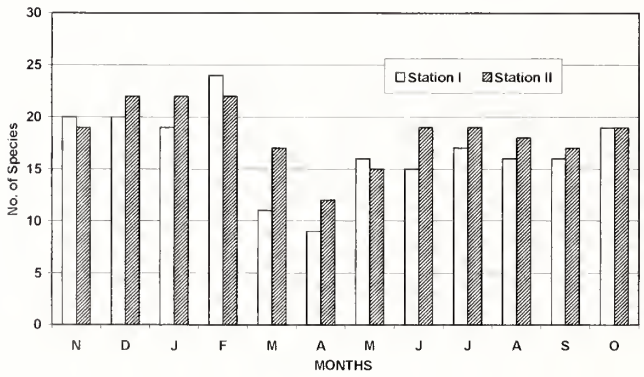

Fig. 2: Chydoridae richness

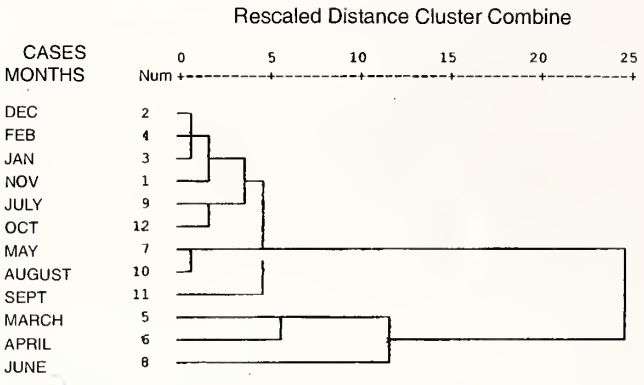

Fig. 3: Dendrogram showing Hierarchical Cluster Analysis between Cladoceran communities (Station I)

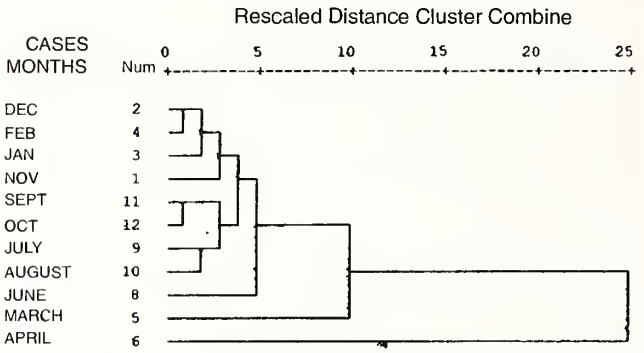

Fig. 4: Dendrogram showing Hierarchical Cluster Analysis between Cladoceran communities (Station II)

minima are recorded during spring and early summer (March *vs.* May at Station I, March *vs.* April at station II). The cluster analysis exhibits higher closeness in composition of Cladocera of the Deepor beel during winter and autumn at the two sampling sites (Figs 3, 4), while spring and summer communities show more qualitative differences. These features may be attributed to a higher richness and common occurrence of several species particularly during November-February as compared with notably lower number of species, as well as differences in their composition during March-May / June.

To conclude, the Cladocera communities of Deepor beel are characterized by rich and diverse nature, qualitative predominance of the facultative planktonic and the littoral-periphytonic species, and exhibit lack of seasonal periodicity of different species or families. The present results indicate influence of only certain individual abiotic factors on the richness while ten abiotic factors register higher commutative influence.

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■ ■ ■

NEW DESCRIPTION

A REVIEW OF THE GENUS *PARAHORMIUS* NIXON WITH DESCRIPTION OF TWO NEW SPECIES (HYMENOPTERA: BRACONIDAE) FROM INDIA[1]

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The Indian species of *Parahormius* Nixon are reviewed. Two species namely, *P. leucopterae* sp. nov. and *P. punensis* sp. nov. are described and illustrated from India. Brief diagnosis of the genus and key to the Indian species of the genus *Parahormius* is provided.

Key words: review, Hymenoptera, Braconidae, Hormiinae, new species, India

INTRODUCTION

Wharton (1993) discussed Genus *Parahormius* Nixon in detail and defined its limits within Subfamily Hormiinae. *Parahormius* is characterized by loss of epicnemial carina, reduction or loss of the pleural flange and carina, relatively narrow prescutellar pits, rather narrow pronotum and occipital carina disappearing ventrally before reaching hypostomal carina.

Most of the species of *Parahormius* are of economic interest as they are gregarious or solitary ectoparasitoids of lepidopteran larvae of the families Coleophoridae, Cosmopterygidae, Gelechiidae and Lyonetiidae (Belokobylskij 1988; Whitfield and Wagner1991; Wharton 1993).

The genus is almost worldwide in distribution but is yet to be recorded from the Australian region. Narendran *et al.* (2002) described four species of *Parahormius* from southern India. In the present work, the Indian species of *Parahormius* are revised. Material pertaining to five out of six species known from India was studied. Also, two new species are described. The genus is rediagnosed, and a key to the Indian species of *Parahormius* is also given. The new species, namely *P. punensis* sp. nov. is based on a single specimen since all avenues of examining additional specimens by borrowing or collecting did not yield any result.

The following abbreviations are used in the text: OOL – ocello-ocular line (distance from the outer edge of a lateral ocellus to the compound eye); POL – post-ocellar line (distance between the inner edges of the two lateral ocelli); AOL – anterior-ocellar line (distance between the inner edges of anterior and lateral ocellus); OD – diameter of an ocellus; ZDAMU – Zoology Department, Aligarh Muslim University.

Genus *Parahormius* Nixon

Parahormius Nixon, 1940: 473. Type species: *Parahormius jason* Nixon, by original designation.

Parahormius Nixon; Hedqvist, 1963: 49

Parahormius Nixon; Shenefelt, 1975: 1151

Parahormius Nixon; Belokobylskij and Tobias, 1986: 64

Parahormius Nixon; Belokobylskij, 1990b: 59-64, 1994b: 15

Parahormius Nixon; Papp, 1990:186

Parahormius Nixon; Whitfield & Wagner, 1991: 740

Parahormius Nixon; Wharton, 1993: 150

Diagnosis: Head smooth or nearly so and sparsely setose dorsally; antennae slender; mesoscutum with a narrow and usually smooth median depression between notauli; notauli narrow and shallow posteriorly, impressed anteriorly; scutellum gently rounded laterally; scutellar sulcus shallow and comparatively narrow; precoxal sulcus and mesopleuron smooth; propodeum areolate; vein 2m-cu of hind wing present; vein M+CU of hind wing about as long as vein 1M; vein 1M of fore wing largely unsclerotized; vein 2m-cu of fore wing postfurcal; vein cu-a of hind wing present, short; first tergite completely sclerotized medially with lateral areas of tergite comparatively narrow; ovipositor sheaths somewhat widened.

Key to Indian species of the genus *Parahormius* Nixon

1. Fore wing with 3-SR shorter than or equal to r; fore wing shorter than body 2
— Fore wing with 3-SR longer than r; length of fore wing distinctly longer than body 5
2. Antennae with 19 segments ..... *P. jason* Nixon
— Antennae with more than 19 segments 3

3. Malar space 0.16x as long as eye length ..... *P. zonus* Narendran
— Malar space more than 0.2x as long as eye length 4
4. T1 of gaster whitish; sternaulus weakly crenulate: mesonotal disc smooth, without longitudinal furrow ..... *P. diephobus* Nixon
— T1 yellowish; sternaulus crenulate; mesonotal disc smooth with longitudinal furrow ..... *P. leucopterae* sp. nov.
5. Antennae 17 segmented, shorter than body; scutellar sulcus narrow and smooth ..... *P. punensis* sp. nov.
— Antennae with 19 or more segments, longer than body; scutellar sulcus narrow and crenulate 6
6. Ovipositor a little shorter than hind metatarsus; mesosoma shorter than metasoma ..... *P. stom* Narendran
— Ovipositor longer than hind metatarsus; mesosoma equal to or longer than metasoma 7
7. OOL: POL = 7: 4; notauli indicated by a pair of longitudinal carinae ..... *P. rameshi* Narendran
— OOL: POL= 8: 3; notauli not distinct *P. absonus* Narendran

1. ***Parahormius absonus*** Narendran

Parahormius absonus Narendran, 2002:56

Material Examined: 1 ♀, **Paratype**: INDIA: Kerala, Walayar, 9.ix.1989, Coll. T.C. Narendran and party (ZSIC).

Host: Unknown.

Distribution: INDIA: Kerala.

2. ***Parahormius leucopterae*** sp. nov.

(Figs 1-3)

Female: Length of body, 1.9 mm; fore wing, 1.6 mm.

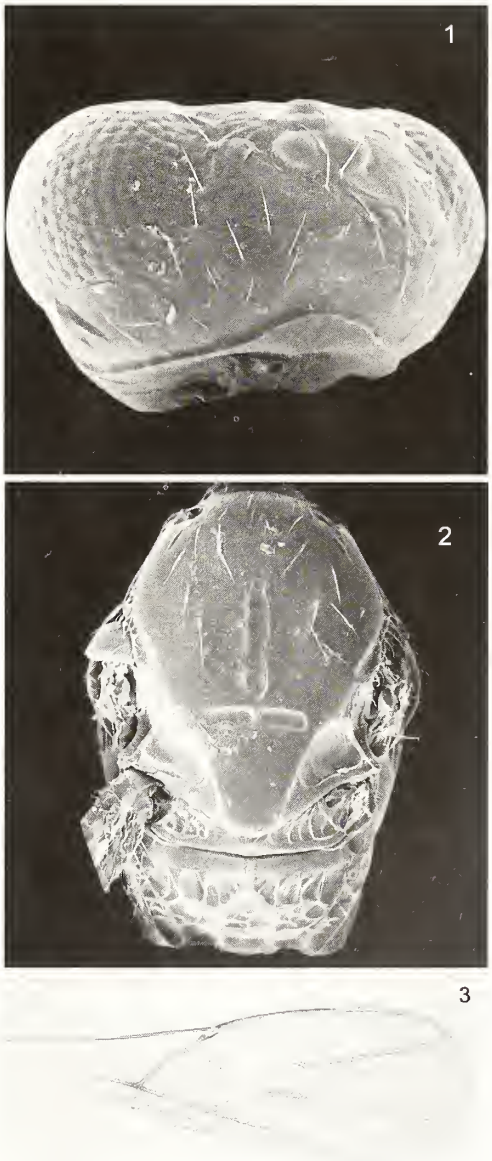
Head: 1.5x as wide as long in dorsal view, 0.9x as high as long in ventral view; eyes 3x as long as temple; eyes large, 1.5x as long as wide, inner margin of eyes parallel; temple punctate, sparsely hairy; ocelli small, elliptical, forming an equilateral triangle; AOL: POL: OD: OOL=1: 1: 1: 3; malar space 0.3x as long as length of eye, 2x base of mandible; face sparsely hairy, slightly convex, punctate, 1.1x as wide as long; clypeus punctate, distinctly separated from face, slightly convex, 2.2x as wide as long; frons smooth and shiny; vertex punctate, sparsely hairy; antennae 22 segmented, 0.8x as long as body, scape 1.3x as long as wide, F_{1}- F_{18} 1.7x and F_{19} 2.6x as long as wide respectively.

Mesosoma: 1.8x as long as wide in dorsal view, 1.7x as long as high in lateral view; pronotum short; mesonotum polished; notauli broad, smooth, distinct only basally; median lobe of mesoscutum with a median longitudinal furrow posteriorly; scutellar sulcus narrow, straight and smooth; scutellum smooth and polished; propodeum with pentagonal areola and reticulation of carinae; propleuron with transverse striations; mesopleuron dorsally with transverse striations otherwise smooth and polished; sternaulus smooth.

Wings: Fore wings 3x as long as wide; 0.8x as long as body length; pterostigma 3.4x as long as wide, 0.9x R1a, r arising from its middle; r 0.8x as long as pterostigma; 3-RSa 0.7x as long as r, 0.5x 2RS, 0.15x 3RSb; r-m 1.3x 3RSa; 2CUb arising from a little above middle of first discal cell; marginal cell slightly narrower towards apex; 1RS straight; 2m-cu postfurcal; 1cu-a postfurcal; hind wing 5x as long as wide.

Legs: Hind femur 3.7x as long as wide; hind tarsus 0.9x as long as hind tibia; hind basitarsus 0.7x as long as tarsal segment 2-4 combined.

Metasoma: 1.2x as long as mesosoma; T1 sclerotized, with longitudinal striations apically, basally smooth,



Figs 1-3: *Parahormius leucopterae*, sp. nov. female:
1. Head, dorsal view; 2. Mesosoma, dorsal view; 3. Fore wing

widening markedly above and below the spiracles, spiracles present one- third basally, 1.2x as long as its apical and basal width respectively; rest of the tergites sub-sclerotized, tergites (2+3)-6 with lateral much darkened, sclerotized patches; patches of T6 joined to form a broad sclerotized band right across the tergite, tergite 7 fully sclerotized; ovipositor sheaths blunt and sparsely hairy, 2.3x as long as basitarsus, 4.6x as long as T1, 0.3x as long as fore wing.

Colour: Face, mesonotum, scutellum yellowish brown; frons, vertex, antennae, legs, metasoma, propodeum yellowish; mandible except its tip; stemmaticum, tip of mandible, ovipositor sheaths brown; ocelli transparent; eyes black; wing hyaline, pterostigma pale yellow, veins brown.

Male: same as female.

Holotype ♀: INDIA: Uttar Pradesh, Aligarh, 14.viii.2005, ex. *Leucoptera sphenogrpta* on *Dalbergia sisso*, Coll. Anjum (ZDAMU). **Paratypes**: 4 ♀, 2♂, same collection of data as holotype.

Host: *Leucoptera sphenograpta* on *Dalbergia sisso.*

Type Locality: INDIA: Uttar Pradesh.

Etymology: The species name is based on the name of its host.

Remarks: *Parahormius leucopterae* sp. nov. is closely related to *Parahormius diephobus* Nixon. However, it differs from *P. diephobus* in having (1) Antennae 22 segmented, 0.8x as long as body (antennae 23 segmented in *P. diephobus*), (2) Malar space 0.3x as long as length of eye (malar space 0. 2x as long as length of eye in *P. diephobus*), (3) Vertex punctuate (vertex somewhat smooth in *P. diebhobus*).

3. ***Parahormius deiphobus*** Nixon

Parahormius deiphobus Nixon, 1940: 479.

Parahormius deiphobus Nixon; Hedqvist, 1963: 49

Material Examined: 2 ♀♀, 1♂: INDIA: Uttar Pradesh, Aligarh 26.v.2005, ex. *Leucoptera sphenograpta* on *Dalbergia sisso*, Coll. Anjum.

Host: *Leucoptera sphenograpta.*

Distribution: INDIA: Uttar Pradesh.

4. ***Parahormius jason*** Nixon

Parahormius jason Nixon, 1940: 478;

Parahormius jason Nixon; Hedqvist, 1963:49.

Parahormius jason Nixon; Chatterjee & Misra, 1974: 89.

Parahormius jason Nixon; Narenderan Rajmohana, Karmaly and Jobiraj, 2002:57.

Material Examined: 3♀♀: INDIA: Punjab. Changa Manga Pltn. 13.iv.1938.Collector not stated (F.I.R.); INDIA: Uttar Pradesh Aligarh, 5 ♀♀, 26.v.2005, 2 ♀♀, 8.v.2005, Coll. Anjum (ZDAMU).

Host: *Leucoptera sphenograpta* Meyrick on *Dalbergia sisso.*

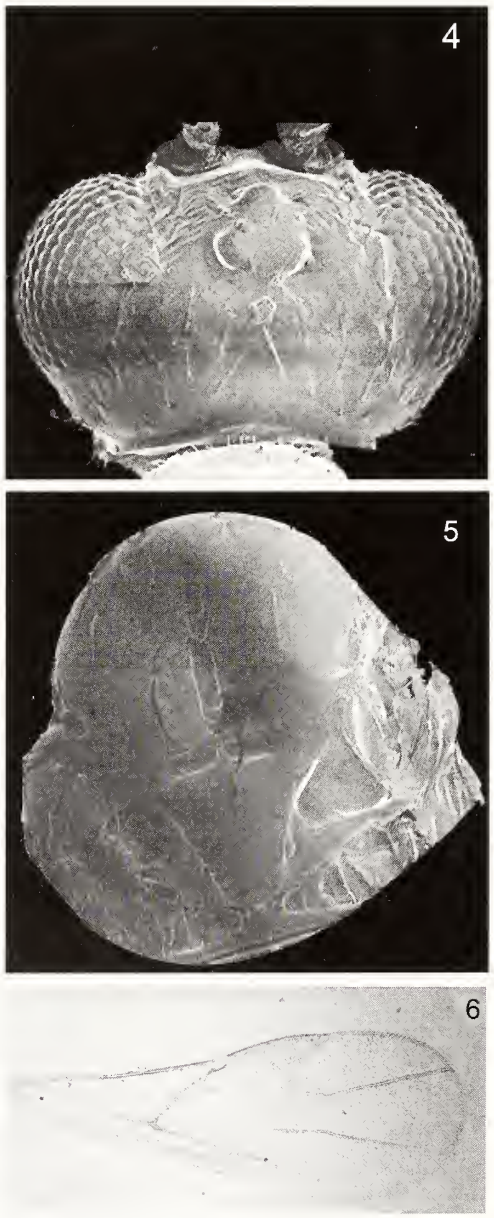
Distribution: INDIA: Uttar Pradesh.

5. ***Parahormius punensis*** sp. nov.

(Figs 4-6)

Female: Body: 1.6 mm long; fore wing: 1.7 mm long

Head: 1.6x as wide as long in dorsal view, 1.1x as high as long in ventral view; eyes large, 4.5x as long as temple; 1.5x as long as wide, inner margin of eyes parallel; ocelli small, elliptical, forming an equilateral triangle; AOL: POL: OD: OOL = 2: 2: 1: 4; malar space 0.3x as long as length of eye,



Figs 4-6: *Parahormius punensis* sp. nov.
female: 4. Head in dorsal view; 5. Mesosoma, dorsal view; 6. Forewing

1.5x base of mandible; face sparsely hairy, smooth and polished, 1.4x as wide as long; clypeus convex, polished, distinctly separated from face; vertex, temple and frons smooth and sparsely hairy; antennae 17 segmented, 0.9x as long as body, scape 2x as long as wide, F_1 2.5x, F_2 2x as long a wide, rest of the segments 4x as long as wide, apical segment tapering.

Mesosoma: 1.9x as long as wide in dorsal view, 2.4x as long as high in lateral view; pronotum smooth, sparsely hairy; mesonotum smooth and polished with a median longitudinal furrow in posterior half; scutellar sulcus rather long and smooth; scutellum slightly convex, smooth and polished, side of scutellum concave and smooth; metanotum with longitudinal striations; propodeum areolate, with a pentagonal areola, having a short median carina present anteriorly, inside of areola transversely rugose, side of propodeum reticulate rugose; popleuron smooth and polished; mesopleuron anteriorly with transverse striations, otherwise smooth and polished.

Wings: Fore wings 2.6x as long as wide, 1.06x as long as body length; pterostigma 3.7x as long as wide, 0.8x R1a, r arising from its middle; r 0.2x as long as pterostigma; 3RSa 1.2x as long as r and 0.2x 3RSb; r-m as long as 3-SR; 2CUb arising from distal end of brachial cell; marginal cell slightly narrower towards apex; 3RSb straight; 2m-cu postfurcal; 1cu-a postfurcal; hind wing 5x as long as wide; M+CU 0.5x 1M.

Legs: Hind femur 4.3x as long as wide; hind tarsus 0.9x as long as hind tibia; hind basitarsus 0.8x as long as tarsal segments 2-4 combined.

Metasoma: 0.9x as long as mesosoma; T1 smooth and polished, 1.2x as long as wide apically and basally respectively, distinctly widened at the spiracular tubercles, spiracles present a little above middle of T1, spiracles 1.2x as wide as long, 1.5x as wide as apical and basal width of T1; rest of the tergites subsclerotized and smooth; ovipositor sheaths blunt and sparsely hairy, 1.3x as long as basitarsus, 2.8x as long as T1, 0.2x as long as fore wing.

Colour: Vertex, face, clypeus, scape yellow with brown markings. Pedicel, mandible except its tip, legs, mesoscutum, scutellum, metasoma yellowish brown; eyes, stemmaticum black; ocelli transparent; pronotum creamish; antennae, tip of mandible, ovipositor sheaths brown; wings hyaline, stigma pale yellow, veins brown.

Male: Unknown.

Holotype ♀: INDIA: Maharashtra, Pune, 7.i.2005, Coll. Anjum (ZDAMU).

Host: Unknown.

Type locality: INDIA: Maharashtra.

Remarks: *Parahormius punensis* sp. nov. is closely related to *P. absonus* Narendran. However, it differs in having (1) Antennae 17 segmented, 0.9x as long as body (antennae 19 segmented, longer than body in *P. absonus*), (2) OOL: POL= 4: 2 (OOL: POL= 8:3 in *P. absonus*), (3) Fore wing 1.2x as long as body with 3RSa 1.2x as long as r (fore wing 1.2x longer than body with 3RSa 2.2x as long as r in *P. absonus*), (4) Scutellar sulcus narrow and smooth (scutellar sulcus narrow, small with longitudinal carinae in *P. absonus*).

6. ***Parahormius stom*** Narendran

Parahormius stom Narendran, Narendran Rajmohana, Karmaly and Jobiraj, 2002:55

Material Examined: **Paratype**: 1 ♀, INDIA: Kerala, Peechi, 5. xi.1989, Coll. Narendran, T.C. and party (ZSIC).

Host: Unknown.

Distribution: INDIA: Kerala.

7. ***Parahormius zonus*** Narendran

Parahormius zonus Narendran; Narendran Rajmohana, Karmaly and Jobiraj, 2002: 53

Material Examined: **Paratype**: 1 ♀, INDIA: Kerala, Vellakkrithadam (Peechi), 5.xi.1989, Coll. Narendran, T.C. and party (ZSIC).

Host: Unknown.

Distribution: INDIA: Kerala.

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REVIEWS

1. ENVIRONMENT AND SELF-ENDANGERED MAN by J.V. Amin. Published by Scientific Publishers, Jodhpur. 2009. 248 pp. Size: 24.5 cm x 19 cm. Hardback. Price: Rs. 2,050/- (INR).

"Cooperation among nations rather than competitive hostility appears to be necessary for preservation of environment and for our survival..." (Preface xi). This sums up the gist of this remarkable book by a professor with knowledge and wisdom of 50 years of academic work. Another remarkable aspect of this book is that most of the reference material used in this book comes from websites. We generally think that 'fossilized' old professors do not depend on modern technology, such as website referencing, but Prof. Amin is different. Nonetheless, he rightly accepts, "The transient nature of some of these websites is a source of some uneasiness to me. When a material is sourced from a traditional library it is there for others to access for a long time, but this may or may not be the case for material that has been taken from Internet source".

The book consists of eight chapters, and three appendices. Each chapter ends with Sources and References, which helps the reader to go to the original source. Most of the internet material referred to is still accessible so the professor need not worry about the 'transient nature' of websites. The book is so modern and futuristic that I got it in mid-2008, although the publication date is 2009!

The book has its blemishes, particularly in the editing part. As I wrote in a review of another book published by the same publisher; Scientific Publishers should get a good editor to check spellings and grammar. For example, in this book, wildlife, watershed, wetlands are always written as two words. Some diagrams are below standard (e.g. page 27). Some of the pictures too are not good, as they were downloaded from the internet (where generally low resolution pictures are uploaded). However, all pictures and tables are properly acknowledged so if a reader wants to know more or go to sources, he/she can easily do so.

In the table on "Wars and violent agitations in the period after Second World War" (pp. 151-153), 45 major conflicts are mentioned, but strangely the condemnable US aggression in Iraq, and subsequent mass killing of civilians (>70,000 according to latest estimates and still continuing) is omitted. I hope this is only an unintentional omission and not by any design. Incidentally, Prof. Amin lives a peaceful retired life in Arizona, USA.

The last chapter, enigmatically titled "Endangered Humans" is worth reading by anyone interested in environmental conservation. As has been rightly said by Prof. Amin, environment is the first casualty of human conflicts. He laments, "Until recently, environment was not considered important and war damage to environment was not recorded". He gives examples of deliberate damage to environment as a war strategy. Who can forget the despicable use of Agent Orange by Americans during the Vietnam War in the 1960s, and the massacre of American Buffalo by the colonists to subdue and finally exterminate the native Americans (20 millions killed). Destruction of infrastructure and dislocation of population can also create significant environmental degradation, because war refugees tend to live off the land as an expediency measure and also because much of peace time activity such as agriculture, industry and trade cannot be practiced for a long time after the hostilities end. We have also seen destruction of wildlife during conflicts. For example, in 1980s and early 1990s, all the Rhinoceros were killed in Laokhowa-Burachapori Wildlife Sanctuary and Manas Tiger Reserve during ethnic conflicts in Assam. In recent years, armed gangs of poachers have devastated the Rhinoceros population in the Chitwan National Park in Nepal during Communist insurgency (or was it 'fight for democracy?').

In Appendix C, Prof. Amin gives data of the death toll of humans by humans, from Mathew White's "Selected Death Tolls of Wars, Massacres and Atrocities before the 20th Century" (http://users.erols.com/mwhite28/Warstat0.htm). It makes sad reading. Looking at the devastation of biodiversity all around, the looming threats of climate change to the life support systems, human population explosion and resultant food scarcity, and increasing loot of natural resources by powerful nations, many books and reports make sad reading. But, will man learn from his mistakes and take corrective measures? This book is silent. I also do not have an answer.

■ ASAD R. RAHMANI

2. BIRDS OF PAKISTAN by Richard Grimmett, Tom Roberts and Tim Inskipp. Published by Christopher Helm, London and Yale University Press, New Haven. 2008. 256 pp. Size: 21.5 cm x 13.5 cm. Paperback. Price not given.

THE BIRDS OF THE INDIAN SUBCONTINENT by Richard Grimmett, Carol Inskipp and Tim Inskipp in 1998, followed by POCKET GUIDE TO THE BIRDS OF THE INDIAN SUBCONTINENT in 1999 by the same authors created a stir in the ornithological

world of South Asia mainly due to their excellent illustrations, change in many common names and quirky taxonomy. Although not comparable to the monumental tome HANDBOOK OF THE BIRDS OF INDIA AND PAKISTAN by Ali and Ripley, the main book (1998) had included recent researches and distribution records of birds. The POCKET GUIDE (1999) became popular and sold thousands of copies. Considering the vast number of bird species found in the Indian subcontinent, Richard Grimmett *et al.* brought out two more books, BIRDS OF NORTHERN INDIA and BIRDS OF SOUTHERN INDIA. With the help of BNHS, these books were translated into eight languages (one language translation is still pending), which also sold thousands of copies and many copies were freely distributed to the frontline staff of the forest department.

Keeping their excellent record, Richard *et al.* have brought out this new book BIRDS OF PAKISTAN, using the same illustrations but updating some descriptions and distribution records. A pleasant improvement is that distribution maps are present on the same page, besides species description.

In 1992, Tom Roberts brought out THE BIRDS OF PAKISTAN in two volumes, which was a seminal work based on 28 years of field research and extensive literature survey. Like the HANDBOOK by Ali and Ripley, it was a reference book on which all other bird books of Pakistan have to be based. I am very happy that Tom Roberts is the second author of the present book under review. His erudition is reflected all over the book.

From the inside cover, it appears that the Urdu edition of this book has also been published with the English version. I hope both these editions will popularize bird watching in Pakistan like similar books have revolutionized bird watching and bird conservation in India. It is sad to know that some species such as the Comb Duck, which are widely distributed in India, have been extirpated in Pakistan, and others such as the Peafowl are found in very restricted areas. I hope this book will make Pakistanis more benign towards wild animals like their eastern neighbour.

■ ASAD R. RAHMANI

3. THE BIRDS OF BORNEO by Clive F. Mann. Published by British Ornithologist's Union and British Ornithologists' Club, UK. 2008. 440 pp. Size: 24.5 cm x 15.5 cm. Hardback. Price not given.

The British Ornithologists' Union (BOU) is well-known for bringing out researched annotated checklists of different regions/countries of the world. This is the 23rd book in the BOU Checklist Series. BOU has already published annotated bird checklists of Angola, St. Helena, St. Lucia, Sumatra, Wallacea, Cayman Island, Morocco and other regions. Like all other books of this series, this is also a valuable addition to ornithological literature.

Borneo is the third-largest island in the world, with more than 630 species of birds. For many genera and species, particularly tropical forest birds, Borneo is the centre of speciation. It has five endemic genera, one endemic monotypic family, and 11% of the resident land birds as endemic. Like all over South-east Asia, the forests of Borneo are under tremendous pressure of deforestation, oil palm plantations, invasive species and bird trapping for commercial trade.

The island of Borneo is important for evolutionists as it is here that Alfred Russel Wallace thought about the theory of evolution, which was around the same time that Charles Darwin proposed his theory on the basis of his work in the Galapagos island, on the other side of the world. Wallace collected birds in the Sarawak region of Borneo (now a part of Malaysia), and later in 1855 wrote about evolution.

This book is based on 10 years of work by Clive F. Mann who spent most of his time in the Negara Brunei Darussalam, a tiny oil rich country in northern Borneo, from 1981 to 1991, and later made short trips in 1993 and 1997. Besides the author's own observations, most of the book is based on literature survey, museum records, personal communications, and reports of field trips by visiting ornithologists. The Reference section runs into 33 pages. The oldest reference is of Alfred Wallace on genus *Pitta* in *Ibis* (1864, 6: 100-114), and the latest is a trip report of 2007 in the internet in html file.

The book is well produced and an excellent update to the rather dated checklist by B.E. Smythies (1957): An annotated checklist of the birds of Borneo published in the difficult to get journal *Sarawak Museum Journal* (7: 523-818).

■ ASAD R. RAHMANI

4. THREATENED MAMMALS OF INDIA: ECOLOGY AND MANAGEMENT by Goutam Kumar Saha and Subhendu Mazumdar. Published by Daya Publishing House, Delhi. 2008. 162 pp. Size: 24 cm x 15.5 cm. Hardback. Price: Rs. 700/- (INR), US $35.

This is a slick volume by two university teachers, but the book does not have anything new about the threatened mammals of India, at least to the conservation community. It will be useful for beginners and students as it has a good

compilation of data on species such as Common Name, Present Status, Distribution, Habitat, Distinctive Characters, Behavioural Biology, Threats to Survival, and Conservation Measures. Such compiled books are useful for writing exams and term papers by students. Unfortunately, there are many spelling mistakes (e.g. cattles). The illustrations are of poor quality and the pictures are just fine. The reference sections runs to only three pages, but relevant references are quoted, including many websites from where the data are compiled. Unfortunately some information is outdated. For example, in the case of Pygmy Hog, there is no mention of successful conservation breeding in Assam and reintroduction of small numbers in the wild.

As both authors have a zoology background, behavioural aspects of species are well written. I recommend this book to college students.

■ ASAD R. RAHMANI

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MISCELLANEOUS NOTES

1. MOVEMENT PATTERNS AND HABITAT USE OF GOLDEN JACKAL *CANIS AUREUS* IN BHAL REGION OF GUJARAT[1]

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The Golden Jackal *Canis aureus* is the most widespread of all jackal species (Sheldon 1992). In India, the Jackal is found in high densities in parts of Gujarat, Maharashtra, Rajasthan and Haryana (Jhala and Moehlman 2004). They are relatively abundant throughout their range. Their usefulness in any ecosystem is as of scavengers and controllers of rodent populations (Sankar 1988; Moehlman 1993).

A few long-term and several short-term studies have been conducted on jackals (van Lawick Goodall and van Lawick 1971; Moehlman 1993; Sharma 1998). The Golden Jackal occupies a variety of habitats by adapting to the varied conditions. Therefore, several aspects of jackal ecology and behaviour are not fully understood. One of the generalized views is that jackals are nocturnal. This study was conducted to investigate the nature of movement patterns and allied behaviour of Golden Jackals in a predominantly agrarian ecosystem. This study, conducted during May-June 2002, was based on continuous monitoring of one radio-collared Golden Jackal.

Study Area and Animal

The study site is in the Bhal region of Gujarat, India. It falls within the Bhavnagar district. Bhal is a semiarid region (Dharmakumarsinhji 1978). Almost all the precipitation occurs during the monsoon, which begins at the end of June and continues till mid-September. October is a transition period with sporadic showers (Jhala 1997). The temperature ranges between 1 °C and 38 °C in winter, which is from November to February. During summer, i.e., March to June, the day temperature normally ranges between 37 °C and 48 °C.

The habitat in the study area comprises of four intermingled ecosystems, namely agricultural, grassland, shrubland and saline habitat. The Golden Jackal shares its habitat with the Wolf *Canis lupus pallipes*, Nilgai *Boselaphus tragocamelus*, Indian Wild Boar *Sus scrofa*, and Wild Fox *Vulpes bengalensis*. Besides, the area supports a variety of rodents (*Tatera indica*, *Millardia meltada*, *Mus booduga*), hare (*Lepus* sp.), birds and insects.

The Golden Jackal individuals had been radio-collared in the study area earlier for home range studies (Aiyadurai and Jhala 2006) as a part of the Wildlife Institute of India's project 'Conservation of the Indian Wolf'. At the start of this study, only one animal survived with an active radio-collar and provided us with good data. This Jackal, an adult male named Don, was radio-collared in December 2000.

Methods

For studying the movement pattern and habitat use, the study animal was followed continuously for two sessions of 72 hours each. The sessions started in the morning and ended at around the same time on the third day, thus covering both diurnal and nocturnal activity. According to Kenward (1987), such data can be used for determining the movement pattern and habitat use despite its limited utility for home range estimation due to the data redundancy effect. But these data give the exact minimum area, which may be a part of the animal's home range, used for that particular period of monitoring.

In this study we used the Telonics telemetry receiver, a 3-element hand held Yagi antenna and a Magellan GPS unit.

For continuous monitoring the procedure remains the same as that for obtaining single independent radio-fixes, the only difference is that the animal is not disturbed and the location is recorded only after the animal moves from that place. Neither homing-in nor triangulation can be used for obtaining exact locations. Homing-in is not used so as not to disturb the animal when it is involved in its normal activities. Triangulation takes time and is not useful when the animal is moving. So, an approximation of the location of the animal is to be made. The error introduced due to this has been discussed by Aiyadurai (2001). Other information on associated animals (whenever sighted), activity, habitat type, nearest village, nearest water source, date and time were recorded in data sheets.

For recording purposes, the habitat was divided into four categories: dense *Prosopis*, medium *Prosopis*, sparse

Prosopis and open fields. In field, visual estimation of the density of *Prosopis* patches in terms of accessibility to human beings was used to discriminate between the habitat types.

Data Analysis

The distances between successive locations were estimated by importing the location data in a GIS domain. This was facilitated by the availability of a previously generated GIS model of the study area in the ongoing project. The time spent at each location was obtained from the associated time data.

The movement data with respect to time was analysed for obtaining the rate of travel and average distance travelled per night and per 24 hours, i.e., the movement patterns. For estimating the time of day preferred for performing a certain activity, the time of day was divided into 8 periods of 3 hours each, and the time spent in each activity was estimated for each period separately.

Estimation of the habitat preference for performing a certain activity was done by sorting the radio-locations first by habitat and then by activity, and then summing the time spent for each activity in each habitat. Habitat and activity data were integrated to know which habitat was preferred for a particular activity. Since the available habitat could not be estimated, we were unable to test whether the habitats were used in relation to their availability.

Results

Movement

On an average the Jackal left its patch for foraging at 1922 hrs (range = 1704 to 2045 hrs, n = 6), and it retired to its resting patch at 0700 hrs (range = 0340 to 0905 hrs, n = 6).

The Jackal moved on an average 8.58 km per night (SE = 2.461, n = 6) and, it travelled this distance at a rate of 0.74 km per hour (SE = 0.203, n = 69 hours) (Table 1). Besides these forays in the night, the Jackal also moved from one patch to another during the daytime. Including this movement, the Jackal travelled an average distance of 9.55 km per 24 hours (SE = 2.361, n = 6). In the first session the distances travelled per 24 hours were 8.82 km, 2.83 km and 4.73 km, whereas in the second session the distance travelled was 9.28 km, 12.71 km, and 18.94 km per 24 hours.

Observations and plots of the movement tracks in the GIS domain showed that the Jackal visited the outskirts of villages regularly and systematically, i.e., from one village to the other taking a circuitous route, which took it back to its resting patch.

Table 1: Distance travelled/night by radio-collared Jackal

Night	Distance travelled/ night (km)	Time elapsed (hours)	Rate of travel (km per hours)
1	5.58	10.8	0.52
2.	1.42	11.3	0.13
3.	5.51	12.1	0.46
4.	9.08	8.2	1.11
5.	11.03	13.8	0.80
6.	18.85	13.1	1.44
Total	51.48	69.3	4.45
Average	8.58	11.6	0.74

Activity and Habitat Use

The data on activity and habitat was pooled for two sessions and the percent time spent in each habitat and percent time spent performing each activity were calculated using the time spent between two successive radio-locations. It was estimated that the Jackal spent 71% of its time resting, 24% moving and 5% feeding. Similarly, it spent 53% of its time in medium *Prosopis* thickets, 35% in dense *Prosopis* thickets, 8% in open fields, and 4% in sparse *Prosopis*.

Fig. 1 shows the percentage of time spent in different activities during different times of the day. The major activity during the daytime was resting while during night it was movement. Feeding was performed for a very short duration during the night hours, when it was actually moving in search of food.

Fig. 2 shows the percentage of time spent in different activities in different habitats. While most of the resting time was spent in the dense and medium *Prosopis* thickets, most of the moving time was spent in open fields and sparse *Prosopis* patches.

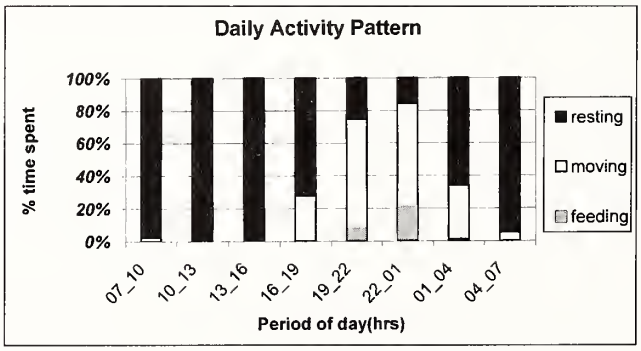

Fig. 1: Proportional time spent in different activities during different times of day by a radio-collared jackal during two sessions of 72 hours of continuous monitoring

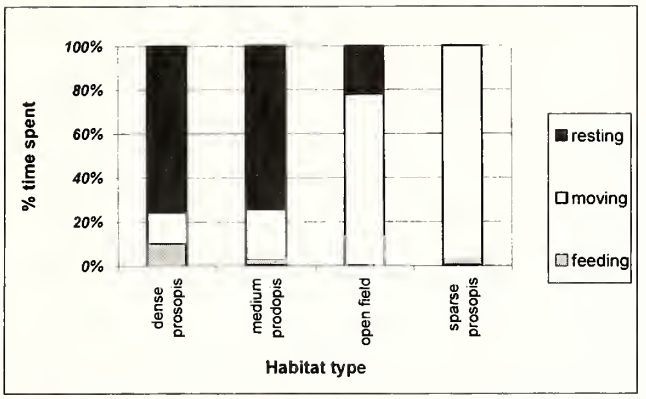

Fig. 2: Proportion of time spent in different activities at different habitats

Discussion

Since the study was conducted for a short duration based on one animal, the result cannot be generalized; but the information generated from continuous monitoring of the radio-collared animal re-confirms the popular belief of its general behaviour.

It can be clearly seen that resting is the dominant activity for the period between 0400 and 1600 hrs. Thus, this Jackal rested for almost the whole day and started moving only at dusk. Occasional movements were also recorded during the daytime, but they were mainly stimulated by the need to attend to the den or by some disturbance, which was almost always human induced.

On an average the Jackal travelled about 8.6 km every night and on an average spent 7-8 hours away from its resting patch foraging only in the night. Moehlman (1986) says that the Jackals go on forays extending up to 5 km. Aiyadurai (2001) has also reported night forays of the Jackals in Bhal to be around 6.2 km. The study animal was also observed to travel in excess of 20 km during one night. In a simultaneous study conducted in the nearby Velavadar National Park, it was observed that carcasses of domestic livestock and fawns, and adults of wild ungulates killed by wolves, featured in the Golden Jackal's diet. The area used by the radio-collared Jackal has an extremely low ungulate density (pers. obs.), and the Jackal was observed to visit the outskirts of villages searching the dumping sites for offal and carcasses of cattle. Although village dumps are abundant, carcasses are very rare. One night the Jackal was observed to systematically visit the outskirts of seven villages, but got a carcass only at one village.

The jackal preferred dense and medium *Prosopis* patches for resting, which was mainly done during daytime, as they provided excellent cover. It was observed moving mostly in open fields and sparse *Prosopis* as while foraging during nights there was no apparent need for cover. This should be the general behaviour of Jackal. The feeding habitat in the study area is generally related to the condition of the dumping sites. Thus, the habitat preference in this case seems to be related to the activity pattern.

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2. IDENTIFICATION OF SCAT OF INDIAN FOX, JUNGLE CAT AND GOLDEN JACKAL BASED ON MORPHOMETRICS

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Carnivore faeces are a valuable source of information for researchers who seek to answer questions of distribution, diet, health, population status, genetic diversity, breeding condition, stress levels and much more of their study animals (Putnam 1984; Reed *et al.* 1997). With several similar sized carnivores coexisting, accurate identification of scats to the species level is imperative. Traditional scat-identification criteria have been based primarily on morphology (Halfpenny 1986; Ciucci *et al.* 1996), which though subjective are rapid, inexpensive and easy to carry out as compared to alternatives, such as bile acid assay through thin-layer chromatography (Major *et al.* 1980), and DNA analysis of scat (Reed *et al.* 1997; Foran *et al.* 1997). Identification of scats of Indian carnivores is still in the domain of natural history (but *see* Mukherjee *et al.* 2004). We present results of a morphometric measurement based analysis of scat of three species of meso-carnivores that occur sympatrically in many areas of their distributional range. Based on this analysis, we conclude that scats of the Indian Fox can be reliably differentiated from that of the Golden Jackal and Jungle Cat, whereas the scats of the latter two species are morphometrically indistinguishable.

We collected scats of the Golden Jackal (*Canis aureus*) and Jungle Cat (*Felis chaus*) from the Sariska Tiger Reserve, Rajasthan and of the Indian Fox (*Vulpes bengalensis*) from the Rollapadu Wildlife Sanctuary, Andhra Pradesh and Ranebennur Wildlife Sanctuary, Karnataka. Scats of the Indian Fox were collected from outside active dens, thus ensuring correct identification. Scats of Golden Jackal and Jungle Cat were identified from bile acid profiles through thin-layer chromatography (Mukherjee *et al.* 2004). We took care to collect scats that seemed to come from a single defecation event. These scats were air-dried upon collection and later oven dried at 60 °C. We took measurements of the diameter at three different locations along the length of each distinct segment of scat using a set of callipers (0.01 cm accuracy). Of these, we chose the maximum width of each scat for comparison.

The mean diameter of scats of Golden Jackal was 1.92 cm (SD = 0.29, 95% CI = 0.052, range = 1.63, n = 124), Jungle Cat was 1.87 cm (SD = 0.28, 95% CI = 0.077, range = 1.04, n = 54) and Indian fox was 1.43 cm (SE = 0.31, 95% CI = 0.063, range = 0.9, n = 55).

Based on the 95% confidence intervals, the results indicated no difference in scat diameter between the Golden Jackal and Jungle Cat, while the Indian Fox scats were smaller in diameter. Therefore, it is possible to differentiate Indian Fox scat from both the Golden Jackal and Jungle Cat scat based on diameter.

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3. AN UNREPORTED POPULATION OF THE GRIZZLED GIANT SQUIRREL *RATUFA MACROURA*[1]

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The Sirumalai Hills are a compact range of hills in Tamil Nadu, southern India. They are located in Dindigul district, with the centre at roughly 10° 13' N, 78° 15' E. The Sirumalais extend over an area approximately 20 km long and 13 km wide. They are outliers of the Western Ghats, close to the Palni Hills. The highest peaks in the Sirumalais are nearly 1,400 m high. A plateau of 1,000 m height is a significant feature of this hill range. The slopes of the hills are fairly steep. The plateau is cultivated and has scanty and degraded natural forest, whereas the slopes are well forested.

While surveying the Sirumalais for birds in 2006 and 2007, we found the Grizzled Giant Squirrel *Ratufa macroura* at various locations (Table 1).

At every instance we saw the squirrels, except at Velampanne, where we only heard their calls. Kolinjipatti is at the foothills, and all the other locations are on the plateau. From our discussions with the staff of Kandighe Estate, we learnt that the animals are regularly seen in their estate and that even three to four animals have been seen together at times.

The Grizzled Giant Squirrel is an endangered species and has been reported from only a few locations in India: the Srivilliputtur Grizzled Giant Squirrel Sanctuary (Joshua and Johnsingh 1994), Chinnar Wildlife Sanctuary (Ramachandran 1989), Kudirayar in the Palni Hills (Davidar 1989), Muttatti in Karnataka (Karthikeyan *et al.* 1992) and Sathanur Dam (M. Krishnan pers. comm. to K.V. Sudhakar). Its total population in India has been estimated at just a few hundred individuals (Joshua and Johnsingh 1994).

The Sirumalai Hills must now be included in the select list of locations where the Grizzled Giant Squirrel is found. Our records of five or six individuals from well-separated parts of these hills suggest that a significant population of this endangered mammal exists here.

Our bird survey was supported by a grant from the Oriental Bird Club. We are grateful to Mr. V. Narayan Swami and the staff of Khandighe Estate for the hospitality and facilities offered.

Table 1: Details of records of the Grizzled Giant Squirrel *Ratufa macroura* in the Sirumalais

Date	Location	Number of individuals	Habitat
August 2006	Kandighe Estate	1	Riverine
April 2007	Horticultural Station	1	Riverine habitat with many old and tall trees as well as introduced trees such as Eucalyptus, Pine and *Grevillea* sp.
July 2007	Velampanne	1	Disturbed forest and silk cotton plantations
September 2007	Kolinjipatti	2, possibly 3	Riverine forest (including tall *Terminalia arjuna*, *Albizzia lebbek*, mango, and tamarind trees); deciduous forest; fruit and coconut plantations

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4. FIELD OBSERVATIONS ON THE CURLEW *NUMENIUS ARQUATA* WINTERING ON THE GULF OF KUTCH COAST[1]

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The Curlew *Numenius arquata* winters on the coast in the Gulf of Kachchh, Gujarat. It breeds in Central Asia; moves to south and south-east Asia during the non-breeding period. The Gulf of Kachchh coast is located at the north of the Saurashtra peninsula in the Jamnagar district of Gujarat, India. The Gulf is exceptionally rich in marine life, and a number of migratory bird species spend the winter here. The long coastline, with broad intertidal mudflats, coral reefs, sandy and rocky beaches offer great diversity of habitats for birds to utilize, and the area is very rich in the diversity and number of both migratory and resident birds. The birdlife of the area has been documented by Abdulali (1962, 1963), Himmatsinhji (1968), Parasharya (1984), Palmes and Briggs (1986), Naik *et al.* (1991), Mundkur (1991), Bhuva and Soni (1998), Soni and Bhuva (2007). The Curlew regularly visits the Gulf of Kachchh during the winter period and uses the coast for feeding and roosting only.

The Gulf of Kachchh, during the last two decades, has been a centre of attraction for several industrial giants, and a number of industries have been established there. Due to these developments, the area is bound to see increase in anthropogenic pressures and related changes.

The Gulf of Kachchh is spread in an area of approximately 7,350 sq. km and has a maximum depth of about 60 m (Hashmi *et al.* 1978); 457.92 sq. km area along the coast of Jamnagar has been notified as a Marine National Park and Sanctuary, and includes 42 islands. Coastal swamps, estuaries, coastal sands, coral reefs and mangrove forest all along the southern part of the Gulf provide foraging grounds to a variety of birds. The Gulf of Kachchh is elongated in east-west direction. At the entrance (63° 05' E) it is about 40 km wide, reduces to a width of 23 km at 69° 44' E, and thereafter slightly widens out before ending at 70° 20' E. The southern coastline of the Gulf of Kachchh is muddy with a few sandy and rocky patches. The vegetation is arid type, dominated by *Euphorbia*, *Acacia*, *Salvadora*, *Capparis* and *Prosopis*. The diversity of marine vegetation is quite poor, the mangrove area is stunted and dominated by *Avicennia marina*, though there is a rich diversity of marine algae (Naik *et al.* 1991).

The study was carried out at Narara Island and Rozybundar. Narara Island is located north of Vadinar town. It is a very small island (22° 25.8' - 22° 28.3' N; 60° 42.1' - 69° 44.7' E), 60 km west from Jamnagar. Length of the island is 0.5 km and width 40 to 50 m during high tide. During low tide, the intertidal area gets exposed up to 2 km. The intertidal area presents mangrove forest, sandy beach, rocky and sandy habitats, and coral reef. Intertidal area of Narara Island is very rich in marine flora and fauna.

Rozybundar (22° 35.6' - 22° 31.7' N; 70° 01.4' - 70° 04.0' E) is situated 10 km north-west to Jamnagar. Kamdar Salt and Chemical Works are situated above the high tide mark. West of the salt-pans is the new port of Jamnagar, to the east of the salt-pans is a privately owned scrub forest, and further east along the coast, are salt-pans of three companies separated from each other on the seaward side by mangrove fringed tidal channels.

The period between November to February shows most of the wintering Curlews on the Gulf coast (Bhuva 1999). The census was carried out from November, 1991 to February, 1992 and from November, 1993 to February, 1994). Data on foraging of the Curlew was collected from January 5, 1993 to February 25, 1993 and December 21, 1993 to February 28, 1994 both at the Narara Island and Rozybunder. Observations were made on adults during day using a telescope and a pair of binoculars from a reasonable distance for a period of 5 min, and effort was made to cover different foraging individuals, through focal sampling, in various parts of the intertidal zone. For rest of the method Soni and Bhuva (2007) was followed.

Roosting

At the time of high tide, all the curlews roosted together either along the coast or islands, or on mudflat of the intertidal zone; they roosted on the eastern and northern side of the Narara Island and the northern coast of the Rozybunder. The average population of Curlews on Narara island was about ten times higher than that of Rozybundar. The highest number of Curlews recorded at Narara Island in January was 209, but only 16 at Rozybundar in December-January. Whimbrel *Numenius phaeopus*, the Caspian Tern *Hydroprogne caspia*, the Bar-tailed Godwit *Limosa lapponica*, the Herring Gull *Larus argentatus*, the Lesser Black-backed Gull *Larus fuscus* and the Crab-plover *Dromas ardeola* were the other species observed roosting at the Narara island.

A selection of the high tide roost was affected by factors such as timings and level of tidal cycle, proximity and availability of a suitable roost and the level of anthropogenic disturbance. The comfortable roosts of neap tides often remained submerged during the high spring tides, and birds roosted on the coast of islands. The activities of fishermen and other people along the coast made it difficult for the Curlew and other waders to use many alternate suitable sites for roosting.

Foraging dispersion

Most of the birds, about 98%, were seen feeding on the mud flat area of the eastern side of Narara Island and northern side of Rozybunder; and some birds in the reef area. Just within 20-50 minutes after the tide started receding, the Curlew got scattered on mud flat and reef for feeding, and foraged actively throughout the period of low tide. At the time the tide started receding, the available foraging area was smaller, the birds usually started feeding much closer (about 2-10 m apart) along the waters' edge. A few individuals spread out over the available mudflat of the upper intertidal zone and fed solitarily. No sooner the available area of the intertidal zone increased with the receding tide then the distance between the birds increased (about 40-70 m). After constant feeding for about 4-5 hours, they slowly clumped, bathed, preened and rested for an 0.5-1 hour before moving to roost.

Foraging and food

The Curlew foraged by both the non-visual and visual tactile foraging methods applying shallow and deep probing. The Curlew preyed upon exposed as well as hiding prey inside its hole. When the Curlew picked up a crab while foraging at mud flats, it washed the mud-covered prey before eating it.

The Curlew used both the feeding modes: walking slowly when searching for hidden prey, and walking quickly when the bird saw some movement on the mud surface.

The number of feeding attempts recorded on foraging was 1,938 which were differentiated into successful and unsuccessful feeding attempts (Table 1). The prey species obtained and identified in the laboratory from 25 mud samples from the foraging sites were Fiddler Crabs (*Gelasimus annulipes*) and Rag-worms. It was difficult to collect regurgitated and faecal pellets as the location of the roost site of the Curlew was in 20-80 mm deep water. Out of 178 successful feeding attempts (Table 1), Rag-worms were identified in 14 attempts and Fiddler Crabs in 164 attempts. Unsuccessful feeding attempts were almost 10 times more than successful feeding attempts.

The Curlew affects harbours, backwaters, sandy seashores, tidal mudflats, creeks, estuaries, and mangrove swamps. The Curlew is a visual as well as tactile forager (Burton 1974) and feeds on a variety of macrobenthic species of prey from the intertidal mudflat. Its prey species include molluscs, seeds, crustacea (largely Fiddler and Sand Crabs), mudskippers, insects and occasionally berries and plant matter (Gooders 1979; Ali and Ripley 1983). Feeding mode in the Curlew varies with the prey availability such as 'Walking slowly' when searching for burrows entrances of benthic animals, and 'walking more quickly' when searching for surface feeding animals. The feeding behaviour and intake rate of the Curlew changed (Zwarts 1997). As per Zwarts and Wanink (1984), the Curlew ignores prey which is unprofitable, i.e., those of which the handling efficiency is below the intake rate during feeding. Caldow *et al.* (2003) mentioned that the Curlew increased in abundance at Mussel (*Mytilus edulis*) cultivation site on the intertidal flats. During the present study the main prey noticed was Fiddler Crabs.

An average number of successful feeding attempts of the Curlew were higher than those of Crab Plovers (Soni and Bhuva 2007). Possibly Curlew used 'Walk slowly' method which leads to a more successful feeding behaviour (Mundkur 1991) than walk-stop-look method used by Crab Plover. On the other hand a non-visual tactile foraging bird probes abruptly into the substrate which may result into either a successful or unsuccessful feeding attempt. However, the Curlew fed both by visual as well as tactile foraging.

Proportion of unsuccessful and successful feeding attempts of the Curlew was about 10:1 (Table 1). Among unsuccessful feeding attempts, a ratio of 'Deep' and 'Shallow Probing' was about 1:3 (Table 1).

Zwarts (1997) suggests that birds take different prey under different conditions and perhaps move away to better sites when the intake cannot meet with the output.

Table 1: Foraging activities of Curlew (*Numenius arquata*)

Foraging activities	Feeding attempts (n)	Attempts /min. mean ± SD
a) Successful feeding attempts	178	0.67 ± 0.37
b) Unsuccessful feeding attempts	1,760	6.74 ± 1.10
i) deep probing	451	1.73 ± 0.48
ii) shallow probing	1,309	5.01 ± 1.02
c) Total feeding attempts	1,938	7.42 ± 1.18

From direct observations on the prey of the Curlew when compared with the Crab Plover, the diversity of prey species of the Curlew was found to be less than that of the Crab Plover (Soni and Bhuva 2007); major (94%) being the Fiddler Crab. Thus, in the Gulf of Kachchh habitat Fiddler Crabs constitute important prey base for the Curlew.

The high tide roost sites are very crucial for the conservation of the Curlews and other waders. Since the Rozybunder faces heavy anthropogenic pressures, number of the Curlews on Rozybunder were extremely low. Thus, for the conservation of the Curlews and other waders it is very important to manage such sites to control the anthropogenic pressure. Otherwise, due to industrialization the pressure is going to increase day by day and the waders may face a variety of problems in the Gulf of Kachchh area.

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5. OCCURRENCE OF ORIENTAL SCOPS OWL *OTUS SUNIA SUNIA* IN MELGHAT TIGER RESERVE, MAHARASHTRA[1]

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I visited Raipur village, north-central part of Melghat Tiger Reserve, Maharashtra, in June 2004 for a status survey of the Forest Owlet (*Heteroglaux blewitti*). This area comes under Forest Division No. 1 of the Melghat Tiger Reserve. The terrain is undulating and hilly. The forest is dominated by Teak *Tectona grandis* in some patches, and mixed forest exists along the streams.

On June 05, 2004, while walking towards a waterhole in the Reserve I was informed by a tribal about a possible case of waterhole poisoning. Tribals in and around Melghat are known to poison waterholes for hunting wild animals. The waterhole was located in forest compartment No. 223, at 21° 34' N and 77° 17' E at an altitude of 550 m. At about 0900 hrs, I reached the waterhole and saw a bizarre sight;

there were two frogs and one rufous bird floating on the water. The frogs and the bird, an owl, were entangled with each other. I do not know the reason behind this. While I was trying to identify the owl, one of our team members found an owl of another species.

Both the specimens were partially damaged, but the key identification characters like wings, legs and plumage were intact. The smaller specimen was 18 cm long and rufous in colour. It had very pale or almost invisible black streaks on its back, the breast had black vertical streaks and the belly feathers were blotched white. I identified it as the Oriental Scops Owl *Otus sunia*. The larger specimen was 25 cm long and brown grey. It had vermiculated lines and streaks on its back. The belly and breast were pale brown and had vertical streaks. I identified it as the Indian Scops Owl *Otus bakkamoena*.

Sawarkar (1987) mentions the presence of Peninsular Scops Owl *Otus scops rufipennis* in the Melghat Tiger Reserve, but my observation is different. There is a very little difference between the Oriental Scops Owl *Otus sunia sunia* and the Peninsular Scops Owl *Otus sunia rufipennis* (Ticehurst 1923; Baker 1927; Ali and Ripley 1987). They differ only in the wing formulae (Ali and Ripley 1987, see museum diagnosis). I identified the specimen up to subspecific level by its wing formulae. In the nominate subspecies *sunia*, first primary is equal to the 7th or 8th, whereas in *rufipennis* the first primary is equal to the 5th or is longer than the 5th. In our case, the first primary was equal to the 8th; hence the specimen was confirmed to be *Otus sunia sunia*.

Sawarkar (1987) mentions "A reference at the sub-species level is included in parenthesis on the basis of reported range of the sub-species. This is not identification at subspecies level". Ali and Ripley (1987) mention presence of a nominate species in north India and some parts of Central India, but there is no clear demarcation on the extent and occurrence of the species. Abdulali (1981) mentions the presence of both the subspecies in Maharashtra. Baker (1927) mentions its presence in Khandesh, which is also a part of Satpuda mountains. Rasmussen (pers. comm.) mentions sympatric occurrence of both *sunia* and *rufipennis* in Toranmal Reserve Forest, which is in Satpuda mountains and only 450 km from Melghat Tiger Reserve. It is possible that like Toranmal both *sunia* and *rufipennis* are sympatric in Melghat Tiger Reserve. However, this needs more meticulous taxonomic work to prove the sympatric occurrence of the two subspecies.

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6. A SIGHT RECORD OF BLUE-CHEEKED BEE-EATER *MEROPS PERSICUS* IN GOA[1]

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During the late afternoon of November 13, 2007, while leading a Sunbird Bird Watching tour to Goa, a group of us visited an area of open grassland near Carambolim (15° 29' N; 73° 57' E). At about 1600 hrs we encountered a flock of about 100 Blue-tailed Bee-eaters *Merops philippinus* perched on some distant wires (Blue-tailed Bee-eater is a common sight throughout much of the coastal plain of Goa). While scanning through them, as I had done with dozens of flocks of this species during my fourteen previous visits to Goa, I noticed a single Blue-cheeked Bee-eater *Merops persicus*. I along with nine other observers watched the bird for a total of about 50 minutes, at ranges initially of about 600 m, but later down to about 30 m. We used a variety of optical equipment between us; I used 8 x 42 binoculars and a telescope on magnifications of up to almost 60x. I was already familiar with the species, mostly from experience in central Asia, and the

bird presented no identification problems. Nevertheless, I recognised its local rarity (I suspected that it had not previously been documented as occuring in Goa), and took some hurried field notes. During my subsequent closer approach I also managed to obtain some identifiable digi-scoped images.

We were able to compare the bird directly with the neighbouring Blue-cheeked Bee-eaters and there were also small numbers of Green Bee-eaters *M. orientalis* in the area for further comparison.

Description

The first thing that caught my attention was the Blue-cheeked Bee-eater's bright green upperparts.

Other features that separated it from the neighbouring Blue-tailed Bee-eaters included – prominent bluish-whitish supercilia above a narrow black ear-covert 'face mask'. The supercilia were short (extending behind the eye by a distance not much more than the diameter of the eye itself), and blunt ended at the rear. They appeared to join narrowly on the forehead.

The Blue-cheeked also lacked any suggestion of a blue hue to its rump and tail with both of these areas being greenish and essentially concolorous with its upperparts. The bird possessed whitish sides to its chin and a similarly coloured narrow horizontal stripe below its black eye mask.

The chin and throat were coppery-orange-paler and less intensely coloured or less 'saturated' than the same feather tracts on the Blue-tailed. The remainder of its underparts were uniformly greenish, being slightly paler than its upperparts.

An orange-copper hue to its underwing coverts, while only seen fleetingly when the bird flew, appeared not very much different to that of the Blue-tailed Bee-eaters, but possibly contrasted more with the darker trailing edge to the secondaries (and possibly inner primaries?).

Structurally the Blue-cheeked Bee-eater appeared very similar to the Blue-tailed Bee-eaters, but was possibly slightly slimmer and 'rangier'. In particular is seemed to be narrower across the body this being especially noticeable in its slimmer rump. The bird's bill also appeared very subtly finer and its crown slightly flatter. The Blue-cheeked Bee-eater's legs were possibly slightly shorter than those of its congeners and, perhaps as a result of this, it more often adopted a horizontal posture when perched on the power lines.

7. MALABAR PIED HORNBILL *ANTHRACOCEROS CORONATUS* PREYING ON SPOTTED DOVE IN BANDHAVGARH NATIONAL PARK[1]

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On March 24, 2006 at 1600 hrs while travelling inside the Bandhavgarh National Park in Madhya Pradesh, India, for fieldwork related to tiger population estimation, I observed a Malabar Pied Hornbill *Anthracoceros coronatus* perched about 45 m away on a *Cassia fistula* tree holding a prey in its beak. After observing through a pair of binoculars (7 x 35) I confirmed that the prey was a Spotted Dove *Streptopelia chinensis*. The Dove was still alive and the Hornbill was trying to kill it by dashing it against the branch on which it was perched. I observed the Hornbill for about 10 minutes, after which the Hornbill flew away with the dead Dove in its beak.

Malabar Pied Hornbill *Anthracoceros coronatus* is mainly frugivorous, but can also subsist on small reptiles, mice and juvenile birds as has been reported by Ali and Ripley (1987). According to BirdLife International (2004), this species is omnivorous, taking fruit, fish and small mammals. However, there are no reports of it feeding on adult Spotted Doves.

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8. OCCURRENCE OF *CHRYSOCOLAPTES FESTIVUS* IN GOA[1]

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Goa is known to be a bird watcher's paradise with varied eco-zones spread over a rather small area with good accessibility. The number of European bird watchers visiting Goa is increasing rapidly day by day. The birdlife of Goa was not well documented till recently with the exception of Grubh and Ali (1976), Rane (1981, 1982), Saha and Dasgupta (1992) and recently Heinz Lainer (1999a, 1999b). Lainer (2004) is a well-researched work of over 15 years and covers 420 species of birds from the coast to the dense forests.

With so much varied avifauna it is not a surprise that a few species could be missed, especially if the species is "widely but sparsely distributed" (Ali and Ripley 1987).

"*C. festivus* is widely but sparsely distributed everywhere: practically all peninsular India with the exception of Sind, West Rajasthan, Kutch and most of Saurashtra in the West, and Assam and E. Pakistan in the East..." (Ali and Ripley 1987). It is described as "widespread" in India by Grimmett *et al.* (1999).

P. Boddaert's 'TABLE DES PLANCHES ENLUMINEEZ D'HISTOIRE NATURELLE DE M.D' AUBENTON' describes Goa as the type locality of the Black-shouldered Woodpecker, *Picus festivus* (=*Chrysocolaptes festivus*). Later, J.F. Gmelin in his SYSTEMA NATURAE (1788-1789) described the Black-shouldered Woodpecker as *Picus goensis* (=*Chrysocolaptes festivus*) (Lainer 2004). Since then, the Black-shouldered Woodpecker does not find mention in any of the publications on the birdlife of Goa except for Lainer (2004), which describes the bird in the Appendix, and contains unconfirmed records of birds that are difficult to identify in the field or are frequently misidentified, or are contentious for various other reasons. He describes it as being "possibly" a rare resident.

This report is an attempt to emphasize and confirm the occurrence of *C. festivus* in Goa. *C. festivus* was first recorded by us on April 23, 2000 at Keri village in the Sattari taluka of North Goa at the foothills of the Sahyadris, when a pair was recorded perching on a topmost dry branch of a *Atrocarpus heterophyllus* tree. Subsequently, it was again recorded in the same village a few kilometres away from the original sighting (Table 1).

Table 1: Incidence of sightings and activity of the *Chrysocolaptes festivus* in Goa

Sr. No.	Date	Area	Sex	Activity
1.	April 23, 2000	Keri, Sattari	1 Pair	Perched on a dry branch of *Artocarpus heterophylus* tree
2.	January 29, 2003	Keri, Sattari	1 Female	Foraging on *Delonix regia* in a mixed hunting party
3.	March 2004	Keri, Sattari	1 Male and 2 Females	Foraging
4.	June 26, 2004	Keri, Sattari	1 Female	Perched on a dry branch of an unidentified tree by the road side
5.	July 02, 2004	Keri, Sattari	1 Pair	Foraging on *Acacia auriculiformes*

The species can be easily identified from the characteristic and prominent black "V" mark on the back, the nape and upper back being white. Another characteristic feature of the species is the yellow crest of the female. The call is also distinct from that of the Golden-backed Woodpeckers.

All the sightings are from only one locality, including one mentioned by Lainer (2004), and records spanning from January to July indicate to it being a breeding resident with a very restricted range.

Incidentally, the area falls on the outskirts of the newly declared Mhadei Wildlife Sanctuary. A year long survey of the Sanctuary by the first author between 2002 and 2003 did not reveal the species. This absence suggests to it being scarce in numbers.

This report would add to the growing list of bird from Goa and at the same time open avenues for more detailed studies of individual species and the avifauna of the State as a whole.

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9. THE LONGEVITY RECORD OF GREATER FLAMEBACK *CHRYSOCOLAPTES LUCIDUS*[1]

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The longevity of many migratory waders has been reasonably well-documented as these birds have been ringed in large numbers (Ali and Hussain 1981; Balachandran 1998). Twelve wader species were recaptured after more than 10 years at Point Calimere. One Garganey *Anas querquedula* ringed at Point Calimere, and one individual each of Northern Pintail *Anas acuta* and Eurasian Wigeon *Anas penelope* ringed at Bharatpur were shot in Russia, 10 years after ringing. One Lesser Sand Plover *Charadrius mongolus* was recaptured after 22 years at Point Calimere (Balachandran and Hussain 1994). Longevity records for Indian birds are rare due to insufficient long-term bird ringing studies in India, in a particular area. However, bird ringing studies of the Bombay Natural History Society at Parambikulam Wildlife Sanctuary, after a gap of 16 years in 1999 under the Bird Banders Training have helped to document an interesting longevity record for the resident Greater Flameback *Chrysocolaptes lucidus*. During a nine day bird banding programme, organized in November 1999 at Parambikulam Wildlife Sanctuary, 101 individuals of 32 species were caught and ringed. Among these, the only Greater Flameback caught had a ring (B-45025) on its left leg. The earlier banding data on the ring indicated that it was ringed in May 1983 from the same locality. The time lapse between capture and recapture was 16 years, 5 months and 24 days. In India, this is the longest longevity record for any passerine bird based on the capture-recapture method.

It is worth mentioning here that 530 birds of 72 species were ringed during 1983 at Parambikulam in 45 days. Of the 530 birds, three Greater Flameback were caught. This recapture shows the territoriality and site-fidelity of this species as it was recaptured from the same locality which has undergone tremendous changes due to increased developmental activities.

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10. OCCURRENCE OF *LANIUS CRISTATUS LUCIONENSIS* IN THE WESTERN GHATS, KERALA[1]

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The status of *Lanius cristatus lucionensis* in India was given by Ali and Ripley (1983) as 'winter visitor to Andaman and Nicobar Islands'. Later it was found to be a regular winter visitor to south-east India based on the records at Sriharikota Island (Mohapatra and Santharam 1992), and ringing data of ten individuals at Point Calimere during

October 1991 by Balachandran and Alagar Rajan (1994). Based on their earlier bird ringing experiences Balachandran and Alagar Rajan (1994) also suggested that some individuals of this species had been mistaken for the *Lanius cristatus cristatus* on the assumption that the plumage difference (greyish white head for *lucionensis* and brown for *cristatus*) was due to age. On January 22, 1999, two individuals of *L.c. lucionensis* were caught and ringed at Parambikulam Wildlife Sanctuary in the Western Ghats of Kerala. Though this species was recorded in 1876 by Hume (1876) in Kerala, it is not listed in the BIRDS OF KERALA by Ali (1969). Hence, this record is not only the second authentic record for Kerala, but from the Western Ghats too. Hume (1876) stated that the plumage characters of the only specimen collected from Kerala did not agree with the specimens obtained from China and the Andamans. The Philippine Shrikes caught at Parambikulam matched with the birds ringed at Point Calimere. However, the Philippine Shrikes caught and observed at Andamans in February 2000, varied in plumage characters from the mainland (Point Calimere and Parambikulam) specimens. The fore-crown of the individual caught at Andamans was paler than the individuals caught at Parambikulam and Point Calimere. The paler fore-crown of the bird handled at Andamans suggests that the wintering population of the Andamans may be from a different geographical population.

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11. SIGHTING OF BLACK-THROATED THRUSH *TURDUS RUFICOLLIS ATROGULARIS* IN THE DESERT NATIONAL PARK, JAISALMER, RAJASTHAN[1]

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At about 1150 hrs on December 03, 2006, while returning from the Sudasri, Desert National Park to Jaisalmer, after birdwatching in the morning, John Penhallurick and I saw a Black-throated Thrush *Turdus ruficollis atrogularis* foraging close to the road near Sam village. We observed and photographed the bird for about five-six minutes. Fortunately, the bird was not shy and allowed close approach to be well observed. The bird was identified as a first winter male Black-throated Thrush.

Black -throated Thrush occurs in winter across Pakistan from the North Western Frontier Province (NWFP) through Baluchistan to the Makran Coast, Sind; the Himalayas and adjacent plains from the Indus Valley and Gilgit eastward through Nepal, Sikkim, Bhutan and Arunachal Pradesh, Nagaland, Manipur, Assam and Bangladesh. Its extension into the plains is governed by winter conditions. The species has occurred fairly often south to Jhang, Ludhiana, Bharatpur and Gorakhpur and has been recorded as far south as Anantpur, Andhra Pradesh and once in Jakhau, Kutch (Ali and Ripley 1998).

Individual birds are occasionally found at great distances from their range. The appearance is invariably correlated with weather, as some individuals wander, especially during hard winter weather (Elkins 1998). The sighting near Sam in Desert National Park represents the first record from the Thar Desert of Rajasthan. Though the sighting of the species near Sam is far to the south of its normal winter range, it is not surprising. The species is known for straggling (Grimmett *et al.* 1998), and has occurred as vagrant to many parts of the Western Palearctic and Middle East in the autumn and early winter (Clement and Hathaway 2000).

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12. 'NEW BIRD DESCRIPTIONS WITHOUT PROPER VOUCHER SPECIMENS': FURTHER TO KANNAN[1]

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Kannan's (2007) review of the issues surrounding the description of the Bugun Liocichla *Liocichla bugunorum* (Athreya 2006) is wide-ranging, fair-minded and good-natured, but in missing a few points and dwelling perhaps too long on others, it requires a little further perspective.

I have deliberately put the main title of my commentary here in inverted commas in order to indicate that it is Kannan's, not mine. This is because I do not share the view that the Bugun Liocichla was described without a proper voucher specimen. This is the first crucial point, which Kannan at first admits, but then spends much time questioning. If it is the case that 'an animal or a part of an animal' is required to serve as the type of a new species under the rules of the International Commission on Zoological Nomenclature (ICZN), then the feathers, including diagnostic ones from the tail, provided by Athreya must be allowed to constitute a 'proper voucher specimen'. Further debate on the issue is irrelevant: Athreya broke no rules, and Kannan's view that feathers are of limited value, and his comment that 'Without a proper voucher specimen, the taxonomic status of the newly reported Liocichla will always be open to doubt', are both, I think, off the mark. The same can be said of all the criticisms and complaints that followed in the wake of the description of *Laniarius liberatus*, for which feathers and blood vouchsafed the existence of the animal from which they came (and which, incidentally, have now been successfully used to demonstrate that *liberatus* is a colour morph: Nguembock *et al.* 2008). A recent exchange (Dubois and Nemésio 2007; Donegan 2008) covers these issues in far greater detail, but reaches the same conclusion.

Kannan points out that photographs can be insufficient to reflect all true characters, yielding a fraction of what is gleanable from a specimen, and can even be doctored or deteriorate. It is, however, worth remembering that photographs can sometimes tell us taxonomically useful things that museum skins cannot, unless the collector has noticed and documented them (eye and bare-part colour in particular, but also jizz). In any case the point about photographs is their great value as supporting evidence, while the point about science is its repeatability — within weeks of the announcement of the new species, birdwatchers and biologists were making their way to Eaglenest to see it for themselves. Athreya's use of photographs was essentially supplementary (although of course they supplied the most convincing testimony of all), and it is worth noting that many modern descriptions of new bird species carry photographs in this support role.

However, there is a crucial issue here, untreated by Kannan or indeed by Athreya (although I mentioned it to the latter in our correspondence), which is that recently a new species of animal was described, in no less a journal than *Science*, using only photographs as the type material (Jones *et al.* 2005). It would be interesting to know how Kannan's museum ornithologists have reacted to this development, rendered all the more surprising by its support by representatives of ICZN (Polaszek *et al.* 2005). To me, this seems a far more problematic circumstance: digital photographs can easily be altered, and I cannot see how this does not expose taxonomy to fraud. Nevertheless, the facts are that (1) since 2005 the notion that photographs alone can form the basis of new species descriptions appears to have received strong (albeit not yet formal) endorsement from ICZN, and (2) photographs of Athreya's undescribed liocichla were circulating on the internet in that year and early 2006. This meant that anyone could have downloaded those photographs and published what in some quarters would have been considered a valid description prior to Athreya, the discoverer and therefore rightful describer of the species. Apart from his concern over the impact that collecting a specimen might have had, Athreya himself gave three reasons for proceeding with his description in the way he did, all relating to conservation; to them may be added this point, that someone else could easily have trumped him, particularly as the time needed for

permission to take a specimen was likely to have been very protracted.

Kannan cites three papers of mine and inclines to agree with the general tenor of them, which is to support collecting in strong terms and to seek greater rapprochement between the museum and conservation communities, but he misses the fact that I make specific provisos over possibly very rare new taxa and those liable to local extinction. This is a crucial area of concern which Kannan does not fully consider. It is not a question of museum scientists being 'bloodthirsty' (I worry that such vocabulary, even when used light-heartedly, risks polarising sensibilities on these issues). It is instead a matter of the appropriate use of the precautionary principle. I accept that the liocichla is likely to be commoner than we currently know, based on Athreya's experience, but we cannot be 100% certain of this. He was therefore in my view entirely correct, ethically and procedurally, to document and name the species without killing a specimen. As he stated, only when it is proved that the species is commoner will it be appropriate to collect a series.

In his introductory paragraphs Kannan says that this case (1) 'may have added fuel to the already widespread feeling that museum collections are no longer necessary for describing new species' and, (2) 'worse, ... may actually make getting scientific collecting permits tougher'. He does not elaborate these points, but in any case I hope both are misapprehensions. First, Athreya took material and donated it to a museum, so (unlike the use of photographs as types in the *Science* paper) it can hardly be said that the case diminishes the need for museum collections. Second, there is no reason why such actions should exert any disruptive influence over the processes of permit issuance: collecting is licensed by bureaucrats according to laws and rules, not according to case history or precedent, so, unless a new law or rule is passed down by policy-makers, the *status quo* on permit issuance is unlikely to change.

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13. HEMIPTERAN FAUNA (INSECTA) INFESTING SANDAL *SANTALUM ALBUM* LINN. IN SOUTHERN INDIA[1]

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Order Hemiptera comprises of a large and diverse group of insects, varying considerably in body form, wings, antennae, life histories, and food habits. The mouthparts of Hemiptera are modified for piercing and sucking plant sap, but in some of the true bugs they are used for sucking blood. Many species are serious pests of cultivated crop plants and forest trees, some species inject toxic materials into the plant while feeding, while some transmit disease causing organisms, and a few Heteropterans are vectors of diseases of warm-blooded vertebrates (Triplehorn and Johnson 2005) These pests damage plants by inserting their mouthparts into plant tissue and sucking juices. Heavily infested plants become yellow, wilted, deformed or stunted, and may eventually die. In the present study, surveys were conducted to document the Hemipteran fauna infesting Sandal plants in nurseries, plantations and natural forests from 2004 to 2006 in southern India; the findings are reported in this paper.

Table 1: Hemipteran fauna infesting Sandal in southern India

	Family	Scientific name	Place of incidence
1.	Aleyrodidae	*Aleurocanthus martini* David	Karnataka
		Aleurodicus dispersus Russell	Karnataka
		Aleurolobus burlierensis Jesudasan & David*	Karnataka
		Dialeurodes icfreae Sundararaj & Dubey	Tamil Nadu
2.	Alydidae	*Leptocorisa acuta* Thunb.	Karnataka
		Riptortus sp.	Karnataka
3.	Cercopidae	*Ptyelus* sp.	Karnataka
4.	Cicadellidae	*Amritodus atkinsoni* (Leth.)	Karnataka
		Batracomorphus brunomaculatus (Evans)	Karnataka
		Batracomorphus sp.	Karnataka
		Calodia kirkaldyi Nielson	Karnataka, Kerala and Tamil Nadu
		Cofana spectra Dist.	Karnataka
		C. unimaculatus (Sign.)	Karnataka
		Exitianus indicus (Dist.)	Karnataka
		Hecalus albomaculatus (Dist.)	Kerala
		Idioscopus clypealis (Leth.)	Karnataka
		I. nagpurensis (Pruthi)	Karnataka
		Kola paulula (Walker)	Karnataka
		Ledra mutica Fabr.	Karnataka, Kerala and Tamil Nadu
		Leofa truncata Viraktamath and Viraktamath	Karnataka
		Macropsis nigrolineata Viraktamath	Karnataka
		Mesargus albimaculata (Dist.)	Karnataka
		Neodartus acocepholoides Melichar	Karnataka
		Nephotettix virescens (Dist.)	Karnataka
		Penthimia compacta Walk.	Karnataka
		Petalocephala sp.	Karnataka
		P. nigrilinea (Walk.)	Karnataka
		Recilia dorsalis (Motsch.)	Karnataka and Tamil Nadu
5.	Coccidae	*Cardiococcus bivalvata* (Green)	Karnataka
		Ceroplastes actiniformis Green	Karnataka, Kerala and Tamil Nadu
		Ceroplastes ceriferus (Fabricius)	Andhra Pradesh and Karnataka
		Parasaissetia nigra (Nietner)	Karnataka and Tamil Nadu
		Saissetia coffeae (Walker)	Andhra Pradesh, Karnataka, Kerala and Tamil Nadu
		Megapulvinaria maxima (Green)	Karnataka
6.	Coreidae	*Cletomorpha* sp.	Karnataka
		Homoeocerus sp.	Karnataka
7.	Delphacidae	*Nilaparvata lugens* (Stål)*	Karnataka and Tamil Nadu
		Sogotella furcifera (Horvath)*	Karnataka
8.	Diaspididae	*Aonidiella orientalis* (Newstead)	Andhra Pradesh, Karnataka, Kerala and Tamil Nadu
		*Fiorinia fioriniae*Targioni Tozzetti	Karnataka
9.	Eurybrachyidae	*Eurybrachis tomentosa* Fabr.	Andhra Pradesh, Karnataka, Kerala and Tamil Nadu
10.	Kerridae	*Paratachardina lobata lobata* (Chamberlin)	Karnataka
		Paratachardina silvestrii (Mohdihassan)	Karnataka
11.	Margarodidae	*Icerya aegyptiaca* (Douglas)	Karnataka
		I. formicarum Newstead	Karnataka
		I. purchasi Maskell	Karnataka
		I. seychellarum Westwood	Karnataka
		Hemaspidoproctus cinerus	Karnataka
		Perissopneumon phyllanthi (Green)	Karnataka
12.	Membracidae	*Leptocentrus longispinus* Dist.*	Karnataka
		L. taurus Fabr.	Karnataka and Kerala
		Otinotus oneratus Walk	Karnataka
		Oxyrhachis tarandus Fabr.	Andhra Pradesh, Karnataka, Kerala and Tamil Nadu
		*O. ruferens**	Karnataka
		Parayasa elegantula Dist.*	Karnataka
13.	Pentatomidae	*Canthecona furcellata* (Wolff)	Karnataka, Kerala and Tamil Nadu
		Erthesina fullo Thunb.	Karnataka and Tamil Nadu
		Halyomorpha picus (Fabr.)	Karnataka
		Halys dentatus Fabr.	Karnataka
		Nezara viridula (L)	Karnataka
		Paracritheus trimaculatus (Le & Serr.)	Karnataka and Kerala
		Plautia fimbriata Fabr.	Karnataka, Kerala and Tamil Nadu

Table 1: Hemipteran fauna infesting Sandal in southern India (*contd.*)

	Family	Scientific name	Place of incidence
14.	Pseudococcidae	*Ferrisia virgata* (Cockerell)	Karnataka
		Nipaecoccus filamentosus (Cockerell)	Karnataka
		Nipaecoccus viridis (Newstead)	Karnataka
		Pseudococcus longispinus (Targioni Tozzetti)	Karnataka
		Rastrococcus iceryoides (Green)	Karnataka
15.	Pyrrhocoridae	*Dysdercus* sp.	Karnataka, Kerala and Tamil Nadu
		D. koenigii Fabr.	Karnataka, Kerala and Tamil Nadu
16.	Scutelleridae	*Chrysocoris* sp.	Karnataka
		Scutellera sp.	Karnataka and Tamil Nadu

*New record on Sandal

The study revealed the presence of 72 species of Hemipterans from 16 families infesting Sandal in India (Table 1), which include 21 species of Cicadellidae followed by 7 species of Pentatomidae, 6 species each of Coccidae, Margarodidae and Membracidae, 5 species of Pseudococcidae, 4 species of Aleyrodidae, 2 species each of Alydidae, Coreidae, Delphacidae, Diaspididae, Kerridae, Pyrrhocoridae and Scutelleridae and one species each of Cercopidae and Eurybrachidae. Of these 6 species, namely *Aleurolobus burlierensis* Jesudasan and David (Aleyrodidae), *Nilaparvata lugens* (Stål) and *Sogotella furcifera* (Horvath) (Delphacidae) and *Leptocentrus longispinus* Dist., *Oxyrachis ruferens* and *Parayasa elegantula* Dist. (Membracidae) are new records. Earlier Mathur and Singh (1961) reported 17 species of Hemipterans and Varshney (1992, 2002) reported two species of scales and mealy bugs infesting Sandal. Remadevi *et al.* (2005) reported eight species of sucking pests, namely *Saissetia nigra* (Nietner), *Saissetia coffeae* (Walker), *Pulvinaria psidii* Maskell, *Pulvinaria maxima* Green, *Ceroplastes actiniformis* Green, *Inglisia bivalvata* (Green), *Tachardina lacca* Mahdihassan and *Aspidiotus* sp. infesting Sandal in nurseries. Sundararaj *et al.* (2006b) reported the occurrence of 23 species of scales and mealy bugs on Sandal, which include seven new records. In the present study though *Pulinaria psidii* was found infesting Teak its infestation on Sandal was not observed, and hence the earlier report from Sandal needs confirmation. Sundararaj *et al.* (2006a) in their review indicated the presence of 411 species of Hemipterans under 43 families in Sandal ecosystem, which included phytophagous insects, predators and casual visitors. The study revealed that less than 100 species of Hemipterans infest Sandal. Among the insect pests known to occur on Sandal the infestation by Hemiptera is deleterious as they affect the normal growth and reproduction of Sandal plants. With the emphasis on growing Sandal as an important plantation crop, along with relaxation of restrictions by the government for growing Sandal for commerce, there is rapid increase in the Sandal acreage in India. Therefore, holistic approach for better management of economically important sucking pests is very much required to increase the production of Sandalwood.

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The authors are grateful to Dr. K.S. Shashidhar, Director, Sri. S.C. Gairola, Coordinator (Research) and Dr. O.K. Remadevi, Head, Wood Biodegradation Division, Institute of Wood Science and Technology, Bengaluru for the facilities provided. Thanks are due to Douglass R. Miller, Research Entomologist, Systematic Entomology Laboratory, USDA, Beltsville, USA and Dr. C.A. Virakthmath, Scientist Emeritus, Department of Agricultural Entomology, University of Agricultural Sciences, Bengaluru, Karnataka for their kind help in identifying the Coccid and Hemipteran specimens, respectively. Financial assistance provided by the Ministry of Environment and Forests, Government of India for conducting this research work, is also acknowledged.

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14. NEW RECORD OF HAWKMOTH *SATASPES TAGALICA* F. *HAUXWELLII* (LEPIDOPTERA: SPHINGIDAE) FROM SANJAY GANDHI NATIONAL PARK, MUMBAI, INDIA[1]

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Introduction

According to Bell and Scott (1937) and D'Abrera (1986), there are 1,354 species and subspecies of Hawkmoths in the world, of which 204 have been recorded from India. Rose *et al.* (2004) recorded 29 species from north-west India, and Sathe and Pandharbale (1999) recorded 13 species from western Maharashtra, including the Western Ghats. Shubhalaxmi and Chaturvedi (2004) has documented 32 species of Hawkmoths during her doctoral studies in the Sanjay Gandhi National Park (SGNP), Mumbai, Maharashtra, which is situated in the northern Western Ghats .

As a part of ongoing ecological study on Hawkmoths of SGNP, I reared a caterpillar of *Sataspes tagalica* f. *hauxwellii* on *Dalbergia latifolia*. This is the first record of *Sataspes tagalica* f. *hauxwellii* from India since the earlier record shows its distribution range to be from Myanmar to Sundaland and Philippines (D'Abrera 1986).

Study area

Sanjay Gandhi National Park (SGNP) is situated in both Greater Bombay and Thane districts, with a total area of approximately 103 sq. km (19° 88'-19° 21' N; 72° 53'-72° 58' E). The Park lies to the west of the Western Ghats and flanks India's western seacoast. It has four types of habitats ranging from mangroves to the evergreen forests of the Western Ghats. The dominant vegetation type of this forest is mixed-deciduous, namely southern India moist-mixed deciduous forest. The Park is divided into two unequal parts; the southern block is more extensive while the northern Nagla block extends over just 16 sq. km. The southern block has a mixed forest, while the Nagla block is characterized by moist-evergreen forest.

Species description

The adult has been identified based on the morphological characters mentioned and illustrated by Bell and Scott (1937), de Niceville (1900) and D'Abrera (1986). The caterpillar was obtained from Nagala block on July 11, 2005 and the adult was released, after photographing it, in the southern block near Goregaon on September 07, 2005.

According to Bell and Scott (1937) genus *Sataspes* (Subfamily Sphingini) has three species: *Sataspes infernalis* (Westw.), *S. tagalica* Boisd. and *S. scotti* Jord. *S. tagalica* has four forms: *tagalica* Boisd., *thoracica* Roths. & Jord., *collaris* Roths. & Jord. and *hauxwellii* de Niceville, of which only the former two are recorded from India. The species was first described by de Niceville (1900) from Taungoo, Upper Tenasserim, Myanmar. Tenasserim is a part of the southernmost division of lower Myanmar (9° 58'-19° 29' N; 95° 48'-99° 40' E) (Anon. 1908).

Sataspes tagalica f. *hauxwellii* Boisduval, 1875

Sataspes hauxwellii de Nicev., 1900

Sataspes tagalica f. *hauxwelli* Roths. & Jord., 1903

Sataspes tagalica hauxwelli Seitz, 1929

Adult: The adult is a day flier and a beautiful mimic of the Carpenter Bee *Xylocopa auripennis*. Interestingly, the female moth mimics the male Carpenter Bee and vice versa. The description of the adult is given by de Niceville (1900). The adult *S. tagalica* f. *hauxwellii* differed from the other three forms by the absence of yellow scales on the thorax and abdomen. The iridescence on wings of adults is seen only in live specimens (Ian Kitching pers. comm.).

Early stages: The early stages of this species have not been recorded, but the early stages of the closely allied *S. infernalis* have been mentioned by Bell and Scott (1937). The caterpillar and pupa are similar to *S. infernalis*.

The caterpillar was reared in captivity within the study area. Pupation occurred inside mud on July 29, 2005, and the adult emerged on September 06, 2005. The pupal period was 40 days, the maximum recorded for Hawkmoths in the monsoon season, so far.

Larval food plant: *Dalbergia latifolia* (Family Fabaceae)

Distribution: INDIA: Mumbai, Maharashtra; Myanmar to Sundaland, Philippines.

ACKNOWLEDGEMENTS

The author is thankful to Dr. Ian Kitching, Natural History Museum, U.K. for confirming the status of the species from their collection; Dr. H.S. Rose, Punjabi University, Patiala for suggesting future studies and Mr. Naresh Chaturvedi, Curator, BNHS for his valuable comments.

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15. *CALAMAGROSTIS PSEUDOPHRAGMITES* (HALL.F.) KOELER VAR. *TARTARICA* (HOOK.F.) BOR (POACEAE) – A NEW RECORD FOR RAJASTHAN[1]

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During a plant collection visit near the Lunkaransar canal, district Bikaner, Rajasthan we collected *Calamagrostis pseudophragmites* (Hall.f.) Koeler var. *tartarica* (Hook.f.) Bor. A perusal of literature shows that this species has not been reported from Rajasthan (Shetty and Singh 1987-93).

This paper records for the first time the occurrence of *Calamagrostis pseudophragmites* (Hall.f.) Koeler var. *tartarica* (Hook.f.) Bor from Rajasthan. It is known, so far, from Jammu-Kashmir, Uttar-Pradesh, Sikkim and West Bengal in India (Moulik 1997). The specimens have been deposited in the Herbarium, Department of Botany, Govt. Dungar College, Bikaner (Rajasthan). The identification of the species is based on Bor (1960).

Calamagrostis pseudophragmites (Hall.f.) Koeler, Descr. Gram. 106.1802. var. *tartarica* (Hook.f.) Bor, Grasses Burma Ceyl. Ind. Pak. 396. 1960; Moulik, Grasses and Bambusa of Ind. Vol II, 395. 1997. *Calamagrostis littorea* P. Beauv. var. *tartarica* Hook.f., Fl. Brit. Ind. 7: 261. 1897 (type K). (Fig. 1).

Perennial, up to 1.6 m tall; Leaf blade broad; Panicle up to 50 cm long, very dense, purple spikelets; Spikelets 3.5 mm long; Glume 3.5 mm long; Lemma 3.5 mm long; Anthers 1.3 mm long.

Specimen Examined: Near canal Lunkaransar, Bikaner, Rajasthan. Kantiya & Sharma 1489, Purohit & Sharma, 3109.

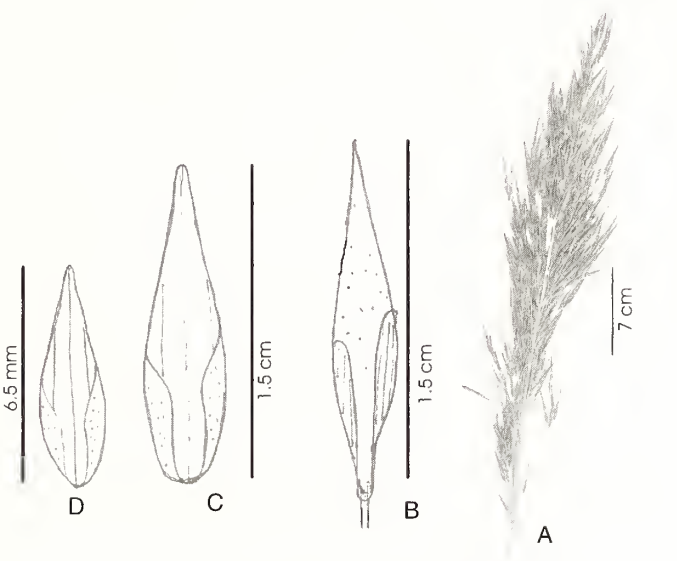

Fig. 1: *Calamagrostis pseudophragmites* (Hall.f.) Koeler var. *tartarica* (Hook.f.) Bor:
A. Inflorescence, B. Spikelet, C. Upper glume, D. Lower glume

Fl. & Fr.: July-September.

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16. A NOTE ON THE OCCURRENCE OF *MELANOCENCHRIS JACQUEMONTII* (POACEAE) IN UTTARAKHAND[1]

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The present communication pertains to the occurrence of the species *Melanocenchris jacquemontii* Jaub. *et* Spach. The voucher specimens and photographic plate with habit and floral dissections are deposited in the Departmental Herbarium BSD and DAV (P.G.) College .

Melanocenchris jacquemontii Jaub. *et* Spach. III Pl. Or. 4: 36, t325. 1851; Bor, Grass. Burma Ceyl. India & Pak., 473, 1960; Cope, Fl. Pak., 125, 1982; Raizada et al., Grass. Upper Gang. Plain - III Pooid. 33, 1983; Nair and Nayar in Bull. Bot. Sur. India. 16(1-4): 142, 1974; Karthikeyan *et al.*, Fl. Ind. Enum. - Monocot. 235, 1998. *Melanocenchris royleana* Nees ex Steud., Syn. Pl. Glum. 1: 218, 1854; Duthie, Fodder Grasses 54, 1888. *Gracilea royleana* (Nees *ex* Steud.) Hook. f., Fl. Brit. India. 7: 284; Blatter & McCann, Bombay Grasses 248, 1935.

Specimens Examined: Uttarakhand, Dehradun district, Raipur, 21.ix.2006, Prakriti Dobhal, ETRL 756 (BSD); Gullarghati, 15.ix.2007, Smriti, ETRL 899 (DAV); Suman Lata, ETRL 900 (DAV).

Fl.: August-September.

Habitat: Found growing in sandy and stony dry river bed.

Distribution: India (drier regions and hillsides), Pakistan, Arabia and Iraq.

ACKNOWLEDGEMENTS

The authors are grateful to the Principal, DAV (P.G.) College, Dehradun and Joint Director, Botanical Survey of India (NC), Dehradun, for providing facilities and encouragement during this investigation. Thanks are also due to the Director, ICFRE, for providing facility to consult the Herbarium.

17. *ARISAEMA TUBERCULATUM* C. FISCHER (ARACEAE) FROM MUKURTHI NATIONAL PARK, NILGIRI BIOSPHERE RESERVE, TAMIL NADU, INDIA – A NOTE[1]

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Biodiversity studies and conservation measures depend on good and up-to-date taxonomic data (Valdecasas and Camacto 2003). Reliable data on the vulnerability of species to extinction and their extinction threats also require sound biological monitoring of tropical ecosystems, which is not limited to a few flagship or umbrella species (Basset *et al.* 2004). Being a core area of Nilgiris Biosphere Reserve, a rapid assessment survey was conducted during 2000-2001in Mukurthi National Park (11° 10'-11° 22' N; 76° 26'- 76° 34' E), to study the herbaceous and orchid flora. This survey is a collaborative project with Tamil Nadu Forest Department, with a view of making an inventory, especially of ephemeral herbaceous forms. Out of 225 species collected and enumerated, 35 species were endemic to the Nilgiri Biosphere Reserve (Vivekananthan *et al.* 1997). Out of these, *Arisaema tuberculatum* C. Fischer is described in detail. The genus *Arisaema* belongs to Family Araceae having about 150 species distributed in East Africa and Arabia, Tropical and East Asia, and West-North America. It was noticed that some species are utilized for medicine and are edible, and commonly referred to as Cobra lily, Dragon-arum and Snail-flower.

Arisaema tuberculatum C. Fischer in Bull. Misc. Inform. 1925: 167. 1925 & in Gamble, Fl., Madras: 1891. Addenda 1936; B. Sharma *et al.*, in Biol. Mem. 2: 151: 1977; Nayar, Hotspots Endem. Pl. India 217. 1996. *A. convolutum* C. Fischer in Bull. Misc. Inform 1934: 165. 1934, non Nakai, 1934.

Dioecious, cormous herb; corm *c.* 6 cm across subglobose. Cataphylls 2 or 3 *c.* 20 cm long, obtuse. Leaf solitary (petioled, *c.* 65 cm long; leaflets 7-12 (-15), 12-38 x 2-9 cm, digitate, sessile, narrowly oblanceolate, finely caudate-acuminate, lateral nerves

c. 20 pairs, anastomising in an intramarginal nerve. Peduncle *c.* 40 cm long. Spathe 7.5-16 cm long, narrowly infundibular, tube 4-6 cm; limb 3.5-10.0 x 3-6 cm, ovate, arching above, acuminate, terminating in a pendant filiform tail of 4-17 cm long. Spadix 5-7 cm long, sessile, erect, cylindric. Pistillate flowers compact. Ovary subglobose, ovules 4; style short; stigma muricate. Staminal flowers scattered; anthers stalked, subglobose dehiscing by pores. Neuters present in pistillate spadix; absent in staminate spadix. Appendix cylindric, swollen in the middle, terminating in a clavate, convoluted tubercle.

Fl. & Fr.: April-June.

Type: Nilgiri Hills, Pennant Shola, Farsons Valley E. Barnes 677 (MH).

Distribution: INDIA: Tamil Nadu. Nilgiri district, Bangitappal.

Ecology: Growing at an elevation of 2,250 m on margins of Shola forests.

Specimens Examined: INDIA: Tamil Nadu, Nilgiri district, Pennant shola, Parsons Valley, 20.v.1933, E. Barnes 677(MH); Bangitappal, 27.iv.2001, V.S. Ramachandran and C.P. Anil Varghese 2899(KNASCH).

Earlier botanists (Gamble 1936; Sharma *et al.* 1977; Ahmedullah and Nayar 1986; Bhargavan 1989) have included this taxon as one of the endemic species highly restricted to upper Nilgiris, Nilgiri Biosphere Reserve and Peninsular India; however, authors Sharma *et al.* 1977, Ahmedullah and Nayar 1986, Bhargavan 1989 differ from one another, while assigning the threat status to the plant as rare (Bhargavan 1989), rare and threatened (Ahmedullah and Nayar 1986); inspite of rarity, and restricted occurrence, this species does not find a place in the Red Data Book of Indian Plants (Nayar and Sastry 1987, 1988, 1990). Due to its niche specificity, occurrence in isolated patches and its ephemeral nature might have led to the non location of this elegant species by earlier botanists (Sharma *et al.* 1977; Ahmedullah and Nayar 1986; Bhargavan 1989).

It differs from its allies in having: spadix cream-coloured, cylindrical with subglobose convoluted, spathe with distinguishing characters – dark purple with 5-7 white bands. It is suggested that this species is a potentially threatened plant, and should be considered for inclusion in the Red Data Book of Indian Plants (Nayar and Sastry 1987, 1988, 1990).

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18. NEW RECORDS OF ORCHIDS FROM ANDHRA PRADESH, INDIA-I[1]

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Floristic survey for orchids was taken up in the east Godavari and Visakhapatnam districts of Andhra Pradesh during November 1994 and October 2005 under an All India Coordinated Research Project on Taxonomy Capacity Building of Orchids, sponsored by the Ministry of Environment and Forests, Government of India. During this survey, 35 orchid species were collected and identified. Voucher specimens were deposited with the herbarium of Regional Plant Resource Centre (REPRECENT), Orissa. The live plants are being maintained in the orchidarium of the Regional Plant Resource Centre. Roxburgh (1795), Elliot (1859), Beddome (1874), J.D. Hooker (1888-1890) and Fischer (1928) in their works did

not report these species from Andhra Pradesh. Ramakrishnan (1997) has not reported these species in his compilation.

During a study of literature and herbaria of the Central National Herbarium (CAL) and Andhra University (AU), six taxa were noted to be new records for Andhra Pradesh. The correct nomenclature, short diagnostic characters, phenology of flowering, ecology, locality, frequency, distribution of these are highlighted.

Acampe rigida (Buch.-Ham. ex J.E. Sm.) Hunt., Kew Bull. 24: 98. 1970; Misra, Orch. Orissa: 587. 2004. *Aerides rigida* Buch.-Ham ex J.E. Smith in Rees, Cyclopaedia 39(78). 1819. *Saccolabium longifolium* (Lindl.) J.D. Hook., F.B.I. 6: 62.1890.

Erect, very robust epiphyte. Inflorescence leaf-opposed erect, rigid, racemose, with one or two short branches. Flowers not wide-opening; perianth fleshy, pale yellow. Lip white, three-lobed, with a large purple blotch within. Column short with two terminal, anterior, back-turned horns.

Fl.: August-September.

Specimen Examined: Bodhuluru (East Godavari); TOB 0125.

Habitat: Moist deciduous or semi-evergreen, thick forests.

Frequency: Rare.

Distribution: India, Bhutan, Myanmar, China, Thailand, Cambodia, Malaysia, Philippines, Sri Lanka, Kenya, S. Africa, Madagascar and Comoro Islands.

Dendrobium moschatum (Buch.-Ham.) Sw., Schrader Neu. J. Bot. 1: 94. 1806; Misra, Orch. Orissa: 427. 2004. *Epidendrum moschatum* Buch.- Ham. in Syme, Emb. Kingd. Ava, ed. 1: 478; with fig. 1800. *Dendrobium calceolaria* Carey ex Hook., Exot. Fl. 3: t. 184. 1827; Hook.f., F.B.I. 5: 744. 1888.

Stems tufted, much elongated. Inflorescence one or two, from a node nearing the apex, usually drooping. Flowers spreading, peach-coloured, musk-scented. Lip clawed, shorter than the petals, pyriform, forming an open-mouthed pouch, with broadly incurved edges, margin undulate; two large maroon blotches below the middle within.

Fl.: May-June.

Specimens Examined: Darakonda (Vishakhapanam); SM 1970; Bodhuluru (East Godavari); TOB 0093.

Habitat: Moist deciduous forests, 600-800 m.

Frequency: Scarce.

Distribution: India, Nepal, Bhutan, Thailand, Bangladesh, Myanmar, China and Laos.

Geodorum recurvum (Roxb.) Alston in Trimen, Fl. Ceylon 6: 276.1931; Misra, Orch. Orissa: 554, 2004. *Limodorum recurvum* Roxb., Corom. Pl.: 33. 1795 *et* Fl. Indica 3: 469.1832. *Geodorun dilatatum* R. Br. in W.T. Aiton, Hort. Kew. ed. 2, 5: 207. 1813; J.D. Hook., F.B.I. 6: 17 (in part). 1890.

Plants with ovoid, compressed, greenish-brown corms. Inflorescence lateral, from base of the newly developed shoots; raceme sub-corymbose, with 6-12 closely set flowers. Flowers white. Lip sessile on the base of the column, white with pink, yellow and brown blotches.

Fl.: May-June

Specimens Examined: Opposite Medicinal Plant Conservation Area (East Godavari); TOB 0108; Kotapalli (Visakhapatnam); TOB 0108A.

Habitat: Moist deciduous open forests, as undergrowth, in moderate shade; with well drained loamy or clayey-loamy soil.

Frequency: Occasional.

Distribution: India; apparently endemic.

Habenaria diphylla Dalz., Hook. J. Bot. 2: 262. 1850; J.D. Hook., F.B.I. 6: 151.1890; Misra, Orch. Orissa: 205. 2004.

Terrestrial tuberoid herbs. Inflorescence terminal, 20-30 cm. long, laxly many-flowered. Flower greenish-white, shortly stalked. Lip three-partite, segments filiform; lateral segments much longer than the middle, apices deflexed; spur inflated.

Fl.: October.

Specimen Examined: Anantagiri (Visakhapatnam); V. Seshavataram; sine no. (AU).

Habitat: Moist deciduous forest, 900 m, on hill slope; medium shade, well drained, sandy or loamy soil.

Frequency: Rare.

Distribution: India, Nepal, Bhutan, Bangladesh, Myanmar, China, Thailand, and Philippines.

Nervilia infundibulifolia Blatt. & McC., *J. Bombay Nat. Hist. Soc. 35*: 735. t.3.1932; Misra, Orch. Orissa: 238. 2004.

Tiny single-leaved plants with globose corms; stolons short, one or two. Leaf prostrate, sub-orbicular, 7-veined. Inflorescence one-flowered. Flower horizontal, mildly sweet-scented. Sepals and petals spreading, linear-lanceolate, sub-similar. Lip three-lobed about the middle; lateral lobes oblong-ovate; apical lobe obovate; disc with three unequal, wavy ridges.

Fl.: June.

Specimen Examined: Wongasava coffee plantation (Visakhapatnam); TOB 0111.

Habitat: Moist deciduous forest, 800 m, on slopy ground, rocky soil with shade.

Frequency: Scarce.

Distribution: India and Thailand.

Vanilla walkeriae Wight, Ic. Pl. Ind. Or. 3(2): 12. t.932.1844-45; . Hook.f., F.B.I. 6: 1890; Fischer in Gamble, Fl. Pres. Madras: 1451. 1928.

Vanilla wightiana Lindl. sensu R.S. Rao & S. Sudhakar, Bull. Bot. Surv. India 26(3-4): 197-200. 1984; sensu, Ramakrishnan 1997.960.

Climbing terrestrial plants, with tendrillar roots. Inflorescence axillary, 8-16 flowers, in dense, simple raceme. Flowers light green, white with pinkish tinge at the base of lip. Lip indistinctly, three-lobed, infundibular.

Fl.: March-April.

Specimen Examined: Surampalem, Rajavomangi reserve forest (East Godavari); R.S. Rao 10193 (AU).

Habitat: Dry scrublands; climbing over small, thorny bushes.

Distribution: India, Sri Lanka.

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19. *BARLERIA LUPULINA* LINDL. (ACANTHACEAE) – AN ADDITION TO THE FLORA OF ORISSA, INDIA[1]

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Introduction

As a part of the project on "Biodiversity characterization at landscape level using Remote sensing and Geographical Information System" in Orissa, the forests of Similipal Biosphere Reserve were surveyed during the period from December 2004 to March 2006. During the course of the survey, the authors came across interesting specimens of a species. After critical examination (Mudgal *et al.* 1997) and consultation with the specimens deposited at the Central National Herbarium (CAL), Kolkata, they were identified as *Barleria lupulina* Lindl.

It finds no mention in the flora of Orissa (Saxena and Brahmam 1989; Saxena and Brahmam 1996; Mishra *et al.* 1999; Reddy and Pattanaik 2006), and is being recorded for the first time.

Barleria lupulina Lindl. in Edwards., Bot. Reg. 18: t.1483. 1832-1833; Clarke in Hook.f., Fl. Brit. India 4: 482. 1884; Mudgal, Khanna & Hajra in Fl. Madhya Pradesh 2: 292. 1997.

Family: Acanthaceae

Undershrubs up to 1 m; young branches tetragonous. Leaves linear-lanceolate, oblanceolate or narrowly elliptic, 5-10 x 0.5-1.5 cm, rigidly coriaceous, glabrous, dark green with red midrib, pale beneath, shortly petiolate; axillary spines in pairs. Spikes erect or nodding 5-8 cm long; bracts broadly obovate, erect, imbricate, green with a purple upper half, thinly pubescent, glands cupular, on the back of the lower half. Calyx lobes 1.0-1.5 x 0.5-0.7 cm, ovate, pubescent; shortly aristate. Corolla lobes 3.5-4.5 cm, subequal, yellow. Stigma bifid. Capsule *c.* 1.5 cm long, ovoid, compressed, beak rigid. Seeds appressed hairy.

Habitat: Rare, in fringes of Sal dominated moist deciduous forests, in the marshy canal bank.

Fl. & Fr.: December-February.

Specimen Examined: Orissa, Mayurbhanj district, Rangamatia, 14.i.2005, Biswal & Mohapatra 266 (North Orissa Univ. Herbarium).

Illustration: Mudgal *et al.* 1997 (*l.c.*).

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20. RECORD OF INTRODUCTION OF A TROPICAL AMERICAN WEED *EVOLVULUS NUMMULARIUS* (L.) L. (CONVOLVULACEAE) IN ANDAMAN AND NICOBAR ISLANDS[1]

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During plant exploration in Little Andaman Island, we collected an interesting creeping herb of Family Convolvulaceae from the grasslands of Hut Bay. After critical study it was identified as *Evolvulus nummularius* (L.) L. and found to be a new introduced weed in the Andaman and Nicobar Islands. A detailed description of this species is provided by Santapau (1947) in the paper titled 'Notes on the Convolvulaceae of Bombay' published in the *J. Bombay Nat. Hist. Soc. 47*: 337-355.

Evolvulus nummularius (L.) L., Sp. Pl. ed. 2. 391. 1762; H. Santapau, *J. Bombay Nat. Hist. Soc. 47*: 341. 1947; Van Ooststroom, Fl. Malesiana 5: 558. 1958; D.A. Powell, *Journ. Arnold Arb. 60*: 229. 1979. *Convolvulus nummularius* L. Sp. Pl. 157. 1753. *Volvulopsis nummularium* (L.) Roberty, Candollea 14: 28. 1952.

Fl. & Fr.: May-August.

Specimens Examined: Little Andaman Island, Hut Bay, Sea level, L. Rasingam 17586 (PBL).

Distribution: Native of tropical America, naturalising in Tamil Nadu, Kerala, Maharashtra and West Bengal states of India.

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21. *TAMARIX PASSERINOIDES* DELILE EX DESV. VAR. *MACROCARPA* EHRENB. (TAMARICACEAE) – A NEW RECORD FOR RAJASTHAN[1]

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During one of the plant collection visits to tehsil Nava, Nagaur district (Rajasthan) we collected *Tamarix passerinoides* Delile ex Desv. var. *macrocarpa* Ehrenb. near Sambhar lake. A perusal of literature shows that this species has not been reported from Rajasthan (Shetty and Singh 1987-93).

This paper records for the first time the occurrence of *Tamarix passerinoides* Delile ex Desv. var. *macrocarpa*

Ehrenb. from Rajasthan. It is known so far from the Khara bet of Gujarat (Pandey 2002). The specimens have been deposited in the Herbarium, Department of Botany, Govt. Dungar College, Bikaner (Raj.). The identification of the species is based on Pandey (2002).

Tamarix passerinoides Delile ex Desv. var. *macrocarpa* Ehrenb. in Linnaea 2 : 276. 1827; Qaiser in Nasir & Ali, Fl. W. Pakistan 141: 40. 1982. *Tamarix macrocarpa* (Ehrenb.) Bunge, Tent. 79. 1852.

Shrubs 0.75-2.0 m high; younger parts densely papillose. Leaves amplexicaul to semiamplexicaul, broadly ovate, ovate-lanceolate, acute to acuminate at apex, deflexed, glandular-punctate. Racemes mostly aestival, simple or rarely compound; rachis papillose; bracts leafy, entire to subentire. Flowers pink to purplish-pink. Sepals 5, each 1.5-2.25 x 1.0-1.5 mm, ovate to trullate-ovate, denticulate, subequal, outer two smaller and more acute than three inner ones. Petals 5, each 3.0-4.5 x 1.5-2.0 mm, obovate to obovate-elliptic. Stamens usually 10, rarely 7-9; filaments alternately long and short, longer filaments 2.5-7.0 mm long, shorter ones 2.0-2.5 mm long. Capsules 10.0-12.0 x 3-5 mm, pinkish-purple. Seeds 0.5-0.7 mm long.

Fairly common in saline habitats.

Specimen Examined: Near Lake Sambhar, Nava, Nagaur. Sharma & Aggarwal, DCH 157.

Fl. & Fr.: October-March.

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22. *ACACIA SALIGNA* (LABILL.) WENDL. (MIMOSACEAE) – A NEW RECORD FOR RAJASTHAN[1]

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During a local plant collection visit to Bikaner district, Rajasthan, we collected *Acacia saligna* (Labill.) Wendl. from near Jaipur road, Bikaner. A perusal of literature shows that this species has not been reported from Rajasthan.

This paper records for the first time the occurrence of *Acacia saligna* (Labill.) Wendl. from Rajasthan. The specimens of *Acacia saligna* (Labill.) Wendl., collected from near Jaipur road, Bikaner, have been housed in the Herbarium, Department of Botany, Govt. Dungar College, Bikaner, Rajasthan.

The identification of the species is based on the Flora of West Pakistan Vol. 36: 1-41, S.I. Ali (1973).

Acacia saligna (Labill.) Wendl., Comm. Acac. Aphyll.: 26.1820. (Fig. 1). *Mimosa saligna* Labill., Pl.Nov. Holl.2:86.t.235.1806.

A tall shrub, phyllode with a prominent midrib, straight or curved, 12-16 cm long, *c.* 7-12 mm broad, tip blunt. Inflorescence pedunculate, heads, arranged

Fig. 1: A. Flowering twig, B. Pod, C & D Flower

in racemose fashion in the axil of phyllodes. Fruits, *c.* 11-13 cm long, *c.* 5-6 mm wide, slightly constricted between the seeds, grayish-brown in colour. Seeds black.

Fl. & Fr.: May-August.

Specimens Examined: Near Jaipur road, Bikaner. Kantiya and Sharma.1234.

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23. ENUMERATION OF SPECIES OF THE GENUS *CORNOPTERIS* NAKAI (ATHYRIACEAE: PTERIDOPHYTA) IN INDIA[1]

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Cornopteris Nakai (Athyriaceae) is a small Asian genus consisting of nine species (Kato 1979), of which four species, namely *C. banajaoensis* (C.Chr.) K. Iwats. & Price, *C. birii* Ching ex Bir, *C. opaca* (D. Don) Tag. and *C. quadripinnatifida* M. Kato were recorded from the east Himalaya (Darjeeling, Sikkim and Arunachal Pradesh) and north-east India (Assam, Meghalaya, Nagaland, Manipur, Tripura). But recently, Fraser-Jenkins (1997) discovered that the description of *C. birii* was based on only one specimen, the type specimen collected by Prof. S.S. Bir from Lachen (north Sikkim), and that it was an immature specimen of *C. decurrentialata* (Hook.) Nakai, and placed it as a synonym of *C. decurrentialata*. However, recently published enumerations of ferns of India, record a varying number of species (Dixit 1984; Chandra 2000), while Vasudeva *et al.* (1990) make no reference of the genus *Cornopteris* in north-east India.

In this paper, an attempt has been made to enumerate the species of *Cornopteris* in India with complete references of synonyms, and distribution in India and the world, along with a note on doubtful records from India to avoid confusion. They are as follows:

1. Fronds bipinnatifid to tripinnatifid:
— Rhizome creeping; pinnule segments entire or denticulate-serrulate ..... *C. decurrentialata*
— Rhizome ascending to erect; pinnule segments entire or shallowly lobed ..... *C. opaca*
2. Fronds tripinnatifid to quadripinnatifid:
— Apex of pinnule segments almost entire or crenate .... *C. banajaoensis*
— Apex of pinnule segments sharply serrate ..... *C. quadripinnatifida*

1. ***Cornopteris banajaoensis*** (C.Chr.) K. Iwats. & Price, Southeast Asian Studies 14: 564 (1977); Kato, Acta Phytotax. Geobot. 30: 112 (1979); Chandra, Ferns India: 142 (2000).

Dryopteris banajaoensis C.Chr., Index Fil. Suppl. 1: 30 (1913).

Dryopteris tenerrima Copel., Philip. J. Sci. Bot. 4: 111 (1909) [non (Fee) Ros. (1906].

Phegopteris banajaoensis (C.Chr.) v.A.v.R., Mal. Ferns & Fern Allies Suppl. 1: 310 (1917).

Athyrium nudum Copel., Fern Fl. Phil. 3: 391 (1960).

Dryopteris fluvialis Hayata, Ico. Pl. Formos. 4: 152.f94 (1914).

Cornopteris fluvialis (Hayata) Tag., Acta Phytotax. Geobot. 1: 158 (1932).

Athyrium fluviale (Hayata) C.Chr., Index Fil. Suppl. 3: 44 (1934).

Dryopteris athyriformis Ros., Hedwigia 56: 344 (1915).

Cornopteris tashiori Tag., Acta Phytotax. Geobot. 1: 159 (1932).

Athyrium tagawai C.Chr., Index Fil. Suppl. 3: 44 (1934).

Cornopteris badia Ching, Bull. Fan Mem. Inst. Biol. Bot. 11: 58 (1941).

Distribution: INDIA: Sikkim; E. Nepal; S.W. China; Philippines; Taiwan; S. Japan; Papua; New Guinea.

2. ***Cornopteris decurrentialata*** (Hook.) Nakai, Bot. Mag Tokyo 44: 8(1930); Fraser-Jenkins, New Sp. Syndr. Indian Pterid. & Ferns India: 93 (1997); Chandra, Ferns India: 143 (2000).

Gymnogramme decurrentialata Hook., Sp. Fil. 5: 142. t. 294 (1864).

Leptogramme decurrentialata (Hook.) J. Smith, Hist. Fil. :232 (1875).

Phegopteris decurrentialata (Hook.) Christ, Farnkr.: 274. f. 865 (1897).

Nephrodium decurrentialatum (Hook.) Diels in Engler

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Dryopteris decurrentialata (Hook.) C.Chr., Index Fil.: 261 (1905).

Athyrium decurrentialatum (Hook.) Copel., Philip. J. Sci. 3: 279 (1908).

Diplazium decurrentialatum (Hook.) C.Chr., Bull. Geogr. Bot. Mans 21: 69 (1911).

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Cornopteris musashiensis Nakai, Bot. Mag. Tokyo 44: 8 (1930).

Athyrium musashiensis (Nakai) C.Chr., Index Fil. Suppl. 3: 43 (1934).

Cornopteris decurrentialata var. *pilosella* H.Ito, Bot. Mag. Tokyo 52: 588 (1938).

Athyrium decurrentialatum var. *pilosellum* (H.Ito) Ohwi, Fl. Jap. Pterid.: 110 (1957).

Cornopteris tsangii Ching, Lingnan Sci. J. 21: 32 (1945).

Cornopteris birii Ching & Bir, Nova Hedw. 7:502 (1964); Mehra & Bir, Res. Bull. Punjab Univ. (n.s.) 15:149 (1964); Dixit, Census Indian Pterid.: 130 (1984).

Distribution: INDIA: Sikkim; Nepal; C. & S. China; Taiwan; S. Korea; Japan.

3. ***Cornopteris opaca*** (D.Don) Tag., Acta Phytotax. Geobot. 8:92 (1939); Dixit, Census Indian Pterid.: 130 (1984); Chandra, Ferns India: 143 (2000).

Hemionitis opaca D.Don, Prodr. Fl. Nepal.: 13 (1825).

Gymnogramma opaca (D.Don) Spr., Syst. 4: 39 (1827).

Phegopteris opaca (D.Don) Mett., Pheg.-Asp.: 15.n.21 (1858).

Leptogramma opaca (D.Don) Bedd., Handb. Ferns Brit. India: 379 (1883).

Dryopteris opaca (D.Don) C.Chr., Index Fil. :280 (1905).

Diplazium opacum (D.Don) Christ, Bull. Geogr. Bot. Mans 1906: 242 (1906).

Athyrium opacum (D.Don) Copel., Philip. J. Sci. 3: 279 (1908).

Gymnogramma obtusata Bl., Enum. Pl. Jav. 2: 113 (1828).

Leptogramma obtusata (Blume) J. Smith, Hist. Fil.: 232 (1875).

Phegopetris obtusata (Bl.) Christ, Farnkr. :274 (1897).

Nephrodium obtusatum (BL) Diels in Enler & Prantl Nat. Pfl.-fam. 1(4): 171 (1899).

Dryopteris bankinsinensis Hayata, Icon. Pl. Formos. 8: 146, f.1.73-74

Dryopteris succulentipes Hayata, Icon. Pl. Formos. 8: 149. f. 77-78 (1919).

Athyrium gymnocarpum Copel., Philip. J. Sci. 40: 301. t. 4 (1929).

Cornopteris likiangensis Ching, Lingnan Sci. J. 21: 32 (1945).

Cornopteris omeigensis Ching, Bull. Fan Mem. Inst. Biol. Bot. 1: 287 (1949).

Cornopteris opaca f. *glabrescens* Kurata, J. Goebot. 12: 41 (1963).

Distribution: INDIA: Darjeeling, Sikkim Meghalaya; Myanmar; S. China; Taiwan; S. Japan; Indo-China; N. Thailand; Philippines; Borneo; Java; Bali; Sulawesi.

4. ***Cornopteris quadripinnatifida*** M. Kato, Acta Phytotax. Geobot. 30: 114.f.11 (1979).

Distribution: INDIA: Uttarakhand, West Bengal, Sikkim; Nepal.

Dixit (1984) reported four species of *Cornopteris* from India, i.e., *C. birii C. macdonellii* (Bedd.) Tard., *C. opaca* and *C. tenuisecta* (Bl.) Tard. Except *C. opaca*, the other three species are now treated as synonyms of *C. decurrentialata*, *Deparia macdonellii* Kato and *Acystopteris tenuisecta* (Bl.) Tag. Khullar (2000) described *C. quadripinnatifida* (a species poorly known in India) as *C. banajaoensis* from Garhwal and Kumaon in Uttaranchal (=Uttarakhand), followed by Chandra (2000), Pande and Pande (2002), Dixit and Kumar (2002) from the same localities. Fraser-Jenkins (pers. comm.) tentatively identified the above specimens, with the remark that it required further confirmation. He has now identified these specimens as belonging to *C. quadripinnatifida,* while *C. banajaoensis* was reported earlier from Uttaranchal in the west Himalaya by Khullar (2000), and by Dixit and Kumar (2002) is *C. quadripinnatifida*. Therefore, *C. quadripinnatifida* is being recorded for the first time from the west Himalaya and thus extends its distribution to Uttarakhand from Sikkim and E. Nepal.

Chandra (2000) enumerated five species of *Cornopteris* from India, namely *C. atroviridis* (v.A.v.R.) M. Kato, *C. banajaoensis*, *C. crenulatoserrulata* (Makino) Nakai, *C. decurrentialata* and *C. opaca*, but he has not recorded *C. quadripinnatifida* in his enumeration. Of them, *C. atroviridis* is a Malayan, Sumatran and Javan species and *C. crenulatoserrulata* is reported only from C. & S.E. China and C. & N. Japan. Both these species have been erroneously recorded from Kumaon Himalaya by Punetha and Kholia (1990) in India. Fraser-Jenkins (pers. comm.) has identified Punetha and Kholia's specimens, collected from Didihat in Pithoragarh district of Kumaon Himalaya in 1996, as *Deparia boryana* (Willd.) Kato [=*Dryoathyrium boyanum* (Willd.) Tard.-Blot]. It is interesting to note that these two species, namely *C. atroviridis* and *C. crenulatoserrutala* have been catalogued (Chandra 2000; Pande and Pande 2002; Dixit and Kumar 2002) from the same locality without verifying and studying these specimens. *C. atroviridis* and

C. crenulatoserrulata do not occur in India and should be excluded from the Indian fern literature to avoid confusion.

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24. *PLAGIOCHILA JUNGHUHNIANA* SANDE LAC. – A NEW RECORD TO INDIAN MAINLAND (NILGIRI HILLS, WESTERN GHATS)[1]

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Introduction

Plagiochila junghuhniana belongs to the Family Plagiochilaceae of Hepaticae. The species was introduced from Indonesia (Java) by Sande Lacoste in 1855. Earlier this species was reported from the Nicobar Islands as *P. berkeleyana* Gott. *ex* Steph. by Stephani (1918). Since then this species has never been collected from India. In a recent publication, *P. berkeleyana* has been treated as a synonym of *P. junghuhniana* Sande Lac (So 2001). During a plant collection trip to the Western Ghats and neighbouring areas this species was collected from the Nilgiri hills, thus showing an extended range of distribution to the Indian mainland. It belongs to *Plagiochila* sect. *Contiguae* in having characteristic oblong-ovate to broadly ovate leaves, moderately decurrent dorsal base of leaves and shortly decurrent ventral base with spinose teeth and medium to large trigones in leaf cells. The most important characteristic of the section is asexual reproduction by leaf propagules developing from ventral surface of leaves (So and Grolle 1999; So 2000). In India, the section is represented by 11 species (*Plagiochila khasiana* Mitt., *P. salacensis* Gott., *P. dissecta* Steph., *P. beddomei* Steph., *P. indica* Mitt. *ex* Steph., *P. nepalensis* Lindenb., *P. acuta* Steph., and *P. junghuhniana* Sande Lac., *P. liebmanniana* Lehm. *et* Lindenb., *P. wightii* Steph. and *P. woronofii* Steph. *ex* Pande *et al.*) out of which the last eight are validly reported from the Western Ghats (Rawat and Srivastava 2007).

Plants decumbent, in compact tufts, up to 45 mm long, 2.8-3.2 mm wide, branching terminal (pseudo-dichotomous), "*Frullania*-type". Stem 13-15 cells across the diameter, differentiated, cortex in 3-4 layers, cells thick-walled, 19-22 x 15-19 µm, medullary cells thin-walled, 30-38 x 22-26 µm. Rhizoids spreading along the basal surface of the stem. Leaves contiguous to sub-imbricate, obliquely inserted, horizontally spreading, oblong-ovate, 1.3-1.6 mm long, 0.63-0.94 mm wide with (4) 6-11 (12) teeth per leaf; dorsal margin straight, entire, base decurrent, apex broad (truncate) with 3-6 teeth, 5-6 cells long, and 3-4 cells wide, ventral margin arched, base ampliate with 2-6 small spines, 4-5 cells long teeth, terminal cell acute, 10 x 21 µm, median cells 34-42 x 26-34 µm, basal cells 38-50 x 26-39 µm, trigones distinct. Underleaves vestigial generally present in the upper sector of plant, may be ciliate or variously toothed. Asexual reproduction by propagules.

Dioecious. Gynoecia always terminal on main shoots, with two innovations; female bracts longer than wide,

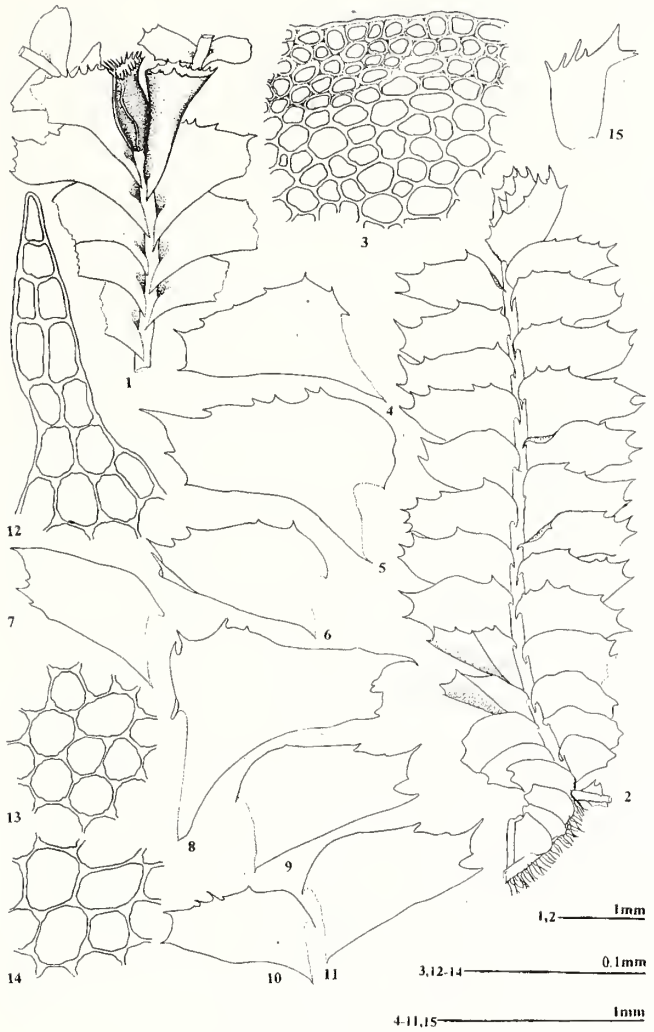

Fig.1: 1-15: *Plagiochila junghuhniana* Sande Lac.
1. Plant, dorsal view; 2. Plant, ventral view; 3. T.S. of stem portion; 4-11. Leaves; 12. Apical cells of leaf; 13. Median cells of leaf; 14. Basal cells of leaf; 15. Underleaf (All figures drawn from LWU 13026/2000)

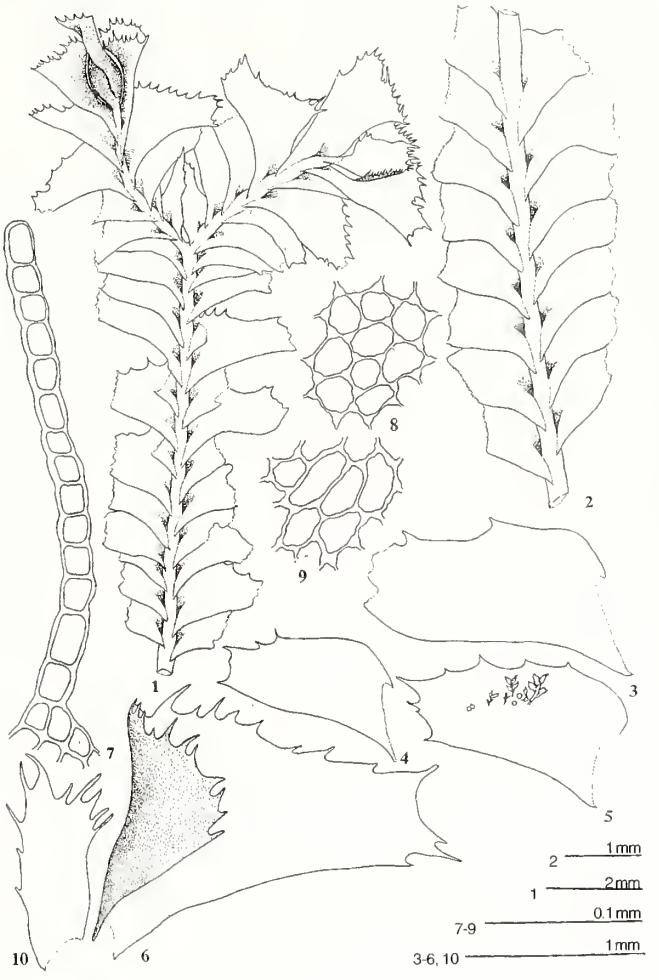

Fig. 2: 1-10: *Plagiochila junghuhniana* Sande Lac.
1. Female plant, dorsal view; 2. Plant showing fragmenting leaves; 3-5. Leaves; 6. Female bract; 7. Apical cells of female bract; 8. Median cells of female bract; 9. Basal cells of female bract; 10. Female bracteole (All figures drawn from LWU 13026/2000)

2.0-2.2 mm long, 1.1-1.2 mm wide, variously toothed, teeth up to 30 per bract; bracteole slightly larger than underleaves, 1.2 mm long and 0.31 mm wide. Perianth cyathiform, immature, apex highly dentate. Sporophyte absent.

Type locality: Indonesia – Java (Inoue 1984).

Range: China, India, Indonesia (Borneo, Java), New Caledonia, Papua New Guinea, Philippines and Thailand (Inoue 1984; So 2001).

Distribution: INDIA: Andaman and Nicobar Islands (So 2001), Tamil Nadu - Nilgiri hills [Coonoor (near municipal bus stand), Gudulur (Cherambadi), Ootacamund (Dodabetta, Kendurai)].

Ecology: Plants growing as terrestrial and epiphytic population on small shrubs.

Specimens Examined: Indo-Malaya: Celebes merid, Tjamba, corticola in siluis primigensis, sciophila; *c.* 1,000 m; J.E. Teysmann; Det.: T.H. Herzog (12538); 1859/60; Hepaticae Selectae *et* Critacae.

India: Western Ghats: Tamil Nadu: Nilgiri hills (Ootacamund-Dodabetta); *c.* 2,660 m, 8.x.2000; S.C. Srivastava and party; 13026/2000 (LWU). Ootacamund (Dodabetta); *c.* 2,660 m, 09.iv.2002; P.K. Verma, A. Alam and N. Sahu; 15380/02 (LWU). Gudulur (Cherambadi); *c.* 1,300-1,400 m; 29.ix.2002; P.K. Verma and A. Alam; 16078/2002, 16079/2002, 16080/2002 (LWU). Ootacamund (Kendurai); *c.* 2,250 m.; 30.ix.2003, P.K. Verma and A. Alam; 16781/2003, 16782/2003, 16785/2003, 16786/2003 (LWU). Coonoor (Near municipal bus stand); *c.* 1,800 m; 16.xi.2006, P.K. Verma and A. Alam; 20020/2006, 20038/2006 (LWU).

Plagiochila junghuhniana is very easily separated from

other species of *Plagiochila* in the Western Ghats as characterized by exclusively bipinnately branched (terminal) plants with oblong-ovate leaves having truncate apex, and margins are rather jagged with up to 11-12 teeth. However, vestigial underleaves are also found, only at the apical shoots. The leaves produce numerous propagules on the ventral surface and one-celled to juvenile multi-celled plantlets may be seen on the same leaf.

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25. LATIN DIAGNOSIS OF *SPIRULINA* (=*ARTHROSPIRA*) *MAHAJANI* MAHAJAN[1]

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In an earlier paper Mahajan, S.K. (2004): A new species of *Spirulina* (=*Arthrospira*) *mahajani* Mahajan from Khargone, Madhya Pradesh. *J. Bombay Nat. Hist. Soc. 101(2)*: 294-295. I had given the details of place, date of collection and location of type material in English, but did not include these details in the latin diagnosis, I wish to remedy this omission by giving a latin rendering of these details here.

Spirulina mahajani Mahajan sp. nov.

Trichomata veneta, libre natanti, non constricta, 4.9-5.6 µm lata, extreme leviter angustiora, ordinate et laxe 3-5 spirata (3.4-5.1 spirata), spirae latitudines fere aequalium, 33-44 µm lata et inter se 39-99 µm distantia; cellulae subquadratae, 2.1-3.6 µm longae; vacuolae gaseosae in cytoplasma uniformiter distributae; cellulae extremorum simplices et calyptra singulari plane conica.

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26. FIG TREES (*FICUS*), CAPTIVE ELEPHANTS, AND CONSERVATION OF HORNBILLS AND OTHER FRUGIVORES IN AN INDIAN WILDLIFE SANCTUARY[1]

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Introduction and background

The endangered Great Pied Hornbill *Buceros bicornis* (GPH) is the largest (length: 120 cm; mass: 3 kg) of the nine species of hornbills (Bucerotidae) in India (Ali and Ripley 1987). Its diet is principally fruits, with a preponderance of figs (*Ficus*) (Kannan 1994; Kannan and James 1997, 1999). The species is affected by a variety of problems ranging from destruction of its wet forest habitat to poaching of adults and squabs from nests (Ali and Ripley 1987), and is listed in Schedule I (most protected) of the Indian Wildlife (Protection)

Act of 1972 (MoEF 2006). The bird is almost always seen foraging or nesting in lofty trees of deep wet-evergreen or moist-deciduous hill forests (Hume 1890; Ali 1936; Ali and Ripley 1987; Kemp 1995), and is therefore apparently dependent on mature old-growth vegetation. No systematic study has been attempted to quantify the foraging habitat preferences of this species. We hereby present quantitative information on a critical component of the foraging habitat-niche of the Great Pied Hornbill (GPH). As explained below, this information enabled us to lobby the Tamil Nadu Forest Department (TNFD) into adopting a policy – a key management strategy to help in conservation of the species.

There is a plethora of evidence in the literature on the importance of *Ficus* as a fruit source for the maintenance of several vertebrate populations (Janzen 1979; Gautier-Hion 1980; Lambert 1989; Lambert and Marshall 1991; Borges 1993), including hornbills (Leighton and Leighton 1983; Kemp 1995; Kinnaird *et al.* 1996; Kannan and James 1997, 1999; Datta and Rawat 2003; James and Kannan 2007; Kannan and James 2007). For the past century or so, Teak (*Tectona grandis*) lumbering operations in the Indira Gandhi Wildlife Sanctuary (IGWLS) in the Anaimalai Hills (Tamil Nadu) of southern India have been assisted by domestic elephants stationed in the protected forests. As a part of the official program to maintain them, mahouts have been traditionally authorized to feed elephants with their favoured forage, which consists of fig leaves harvested from surrounding forests. This practice helped conserve precious funds that would otherwise be allocated for procuring elephant feed.

Between 1991 and 1993, we observed that numerous fig trees inside IGWLS had been lopped repeatedly to feed the approximately 30 elephants stationed in the Sanctuary. Many fig trees in the Top Slip area (Ulandy range) showed telltale signs of having been lopped in the recent past: stunted appearance, truncated boles and branches, and absence of fruiting (despite two years of constant monitoring). The TNFD regarded lopping to be relatively harmless to the trees as it was seldom lethal. The elephants aided in lopping and transporting the bales of *Ficus* foliage from the forests to various elephant camps in the Sanctuary. We also observed that many local avian frugivores, especially GPH, relied heavily on fig fruits for food. Over 90% of all GPH tree visits during one year (September 1991 to August 1992) were to fig trees, compared to 55.7% for four other avian frugivores during the same period, and nearly a quarter of the resident avifauna ate figs (Kannan and James 1999). Considering such heavy dependence on figs by GPH and many other local wildlife species, we collected quantitative data to demonstrate the importance of large fig trees in the foraging habitat of the hornbill. Our goal was to provide the TNFD with data on size of fig trees suitable for GPH, and thereby convince them of the potential negative effects of the *Ficus*-lopping practice on GPH and other vertebrate frugivores.

Study area and methods

The study was conducted in the Top Slip area of the 1,250 sq. km IGWLS. The Sanctuary is a vast mosaic of moist-deciduous or evergreen forests, tea and teak plantations and human settlements (refer Kannan and James 1997, 1999 for more information about the area).

We developed a profile of the foraging habitat by measuring different vegetational characteristics around each of 20 fig trees used by the GPH for foraging, following the approach proposed by James and Shugart (1970) and adopted by Mudappa and Kannan (1999) and James and Kannan (2009, in press). Circular vegetational plots measuring 0.07 ha (radius 15 m) were established around the tree, and 15 vegetational characteristics (Table 1) were measured within these plots. Shrub density was measured by counting stems intersecting a meter-wide stick held at waist height (1 m) along four orthogonal transects established at the centre of each plot. Heights were measured using a clinometer. Canopy and ground cover were determined by making 40 overhead and ground sightings for presence of green vegetation sighted at the cross-wires of a sighting tube at random points along the transects. Emergence of the centre tree is defined as the projection of the centre tree above the rest of the canopy. Data gathered from the foraging plots were compared with an equal number (20) of control samples in which the centre fig tree was chosen by pacing 75 m away from the foraging fig tree in a randomly chosen direction. The nearest fig tree at the end of this distance with a diameter (DBH) of 20 cm or above was used as centre tree, and the vegetational factors measured at the foraging site were measured in a plot centered on the control tree. We observed that 75 m to the control plot was a sufficient distance to evade the forest structure influence of the foraging plot, but still within the same general forest type, and our findings, which follow, showing significant difference between foraging and control plots proved we were correct. We chose 20 cm as the minimum DBH for the control fig trees because that was the minimum size in which fig trees were observed to bear fruit in the area (Kannan and James 1999). All the control trees showed no signs of lopping, and GPH were not observed to forage in those trees. Our aim was to compare fig trees used by GPH, with fig trees available and unused in the area (control fig trees), to test the hypothesis that hornbills choose exceptionally large trees for foraging. Such a comparison between used and non-used trees is important to delineate habitat factors that are crucial for hornbill foraging habitat selection.

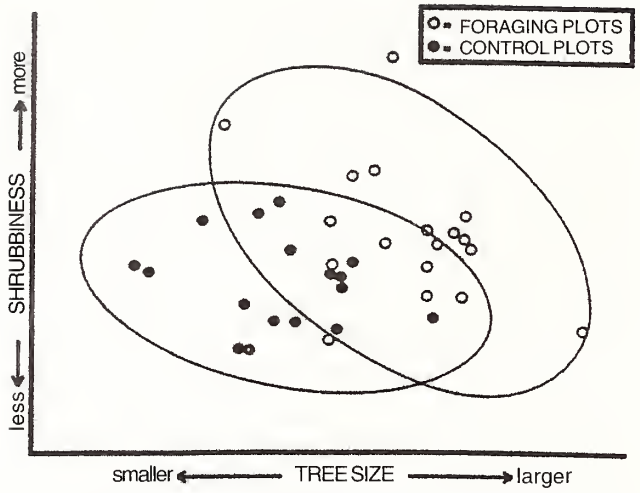

Fig. 1: Ordination, with 95% confidence ellipses, of fig tree foraging plots used by the Great Pied Hornbill and control fig tree plots, based on the scores of the first (tree size) and second (shrubbiness) Principal Components.
(The number of circles, both shaded and open, number less than the requisite 20 each because some plots were so similar that the circles were superimposed.)

We analyzed data using univariate Analysis of Variance (ANOVA) to determine which habitat characteristics used by the hornbill for foraging was significantly different from those of control samples. Principal Components (PC) Analysis (Morrison 1967) was performed to determine the most important factors delimiting the habitat niche of the species. Multivariate Analysis of Variance with step-wise Discriminant Function Analysis (Cooley and Lohnes 1971) was also performed to identify the critical vegetation characteristics involved in separating foraging sites from control ones. All these tests were done using SAS Institute (1985) software.

Results

Results of Analysis of Variance (ANOVA) of 15 vegetational characteristics measured in foraging and control plots (Table 1) showed that the following factors had values that were significantly higher in foraging plots than in control plots: shrub density, average canopy height, tallest tree height, centre tree height, centre tree diameter, and emergence of centre tree above forest canopy. Except shrub density, all other significant parameters represent size of centre tree, indicating that large trees are a critical part of the foraging habitat of the hornbill. PC analysis too emphasized the importance of foraging tree size in hornbill foraging habitat selection. Accounting for 77% of the total variance in the data, the first PC (PC I, Table 1) was highly correlated with the vegetational characteristics named above that directly relate to size and maturity of centre tree: tree height, centre tree diameter, canopy height, height of tallest tree in plot, and emergence of centre tree. PC I could thus be named "centre tree size." PC II, which accounted for an added 14 percent of the total variance (Table 1) could be called 'shrubbiness', since it was correlated heavily with shrub density. Together, PC I and PC II explain more than 90 percent of total variance in the vegetational data measured.

The foraging and control fig trees were clearly separated (Fig. 1) along the environmental gradient (PC I) representing tree size, with foraging plots positioned towards larger centre tree size, and control plots scattered towards the other end of the continuum. This portrayal reinforces the importance of large trees in selection of foraging sites by GPH. Although not obvious visually, the increased shrubbiness of foraging plots is evident by drawing a horizontal line across the figure so that half the combined circles are above the line, half below. Note that about twice

Table 1: Vegetational characteristics that differed significantly* between fig tree foraging sites used by the Great Pied Hornbill and control fig tree sites

Vegetational characteristic	Foraging plot mean (n=20)	Control plot mean (n=20)	*P*	Correlations with Principal Components (PC)	
				PC I	PC II
Shrub density (per 60 sq. m)	72.5	53.3	0.01	0.16	0.54
Average canopy ht.(m)	29.7	25.7	0.005	0.74	-0.24
Tallest tree in plot (m)	35.8	30.4	0.007	0.81	-0.22
Centre tree ht. (m)	35.1	25.4	0.0001	0.96	-0.18
Centre tree diameter (m)	1.73	1.04	0.0001	0.74	0.098
Centre tree emergence (m)	5.4	-0.28	0.001	0.78	-0.06
Percentage of total variance				77	14

*Univariate Analysis of Variance (ANOVA)
+Other characteristics that were measured but did not differ significantly were: per cent canopy and ground cover and number of trees in the plot in the diameter (DBH) classes (cm) 15-30, 30-45, 45-60, 60-75, 75-90, 90-105, and >105.
Underlined values in Principal Components (PC) analysis represent high correlations with their respective PCs.

as many foraging plots than control plots are above the line, indicating increased overall shrubbiness in the foraging plots. Twice as many control plots compared to foraging plots are below the line indicating overall decreased shrubbiness in the control plots.

Three vegetational characteristics were identified by Stepwise Discriminant Function Analysis as most important in providing separations between foraging and control plots. These were: centre tree height, canopy cover, and shrub density ($P = 0.0001, 0.0129$, and 0.0002 respectively), the first two emphasizing the importance of tree size in hornbill foraging.

Discussion

Lopping fig trees to feed captive elephants has apparently been practiced in the IGWLS since the beginning of lumbering operations in late 19th and early 20th century. The findings of this study, and those of concurrently conducted phenology and GPH feeding ecology studies (Kannan 1994; Kannan and James 1997, 1999, 2007) highlighted the importance of large fig trees for GPH foraging, and the 'keystone' (Lambert and Marshall 1991) nature of *Ficus* in the conservation of hornbills and other vertebrate frugivores. In our study area, fig fruits were available year-round, and their availability when other fruits were scarce made them especially important for frugivores (Kannan and James 1999). Moreover, the pattern of fig production significantly increased during the dry and hot months between February and May, coinciding with the breeding season of the GPH (Kannan and James 1999), when the majority of food items (72.9%) delivered by parent hornbills to confined nest inmates were figs (Kannan and James 1997). Non-fig fruits exhibited highly seasonal fruiting patterns, being available only during the dry and hot season. Our findings prompted the TNFD into mandating a total ban on fig tree removal and lopping inside IGWLS in May 1992. Upon prompting from us, the policy was reinforced *via* a circular dated May 12, 1995 from Mr. M. Krishnakumar, I.F.S., Wildlife Warden of IGWLS, to all Range Officers in the sanctuary (M. Krishnakumar, pers. comm.). As of 2001, that directive was still the policy in the department (N. Loganathan, TNFD, pers. comm.). Although violations of the ban still occur sporadically (R. Natarajan, IGWLS, pers. comm., 2001), lopping is no longer systemic in the IGWLS. In addition, the TNFD embarked on (in 1993) a program of trail-side planting 2,000 *Ficus* saplings in the Top Slip area of IGWLS, although none survived because of grazing by wild mammalian herbivores (DJ and RK pers. obs.).

The high shrub density in GPH foraging sites probably resulted from the deposition of seeds in the rain of faeces produced by vertebrate frugivores. This 'seed-rain' and the resulting seedling growth (Guevara *et al.* 2004) may have accounted for the increased density of shrubs beneath GPH foraging sites.

The *Ficus* taxa, with its multitude of coexisting species, contributes significantly to the diversity of tropical forests (Harrison 2005), and thus warrants conservation measures. Frequent lopping of branches, although not often lethal to the tree, results in stunted vegetative growth, and may negatively affect production of fig fruits. This could adversely limit food and nutritional availability (O'Brien *et al.* 1998; Wendeln *et al.* 2000) for frugivores, and thus affect the survival of GPH. Given the critical roles played by hornbills as seed-dispersal agents (Kinnaird 1998; Kitamura *et al.* 2004), it follows that systemic lopping of fig trees could lead to serial local extinctions within forest ecosystems by jeopardizing key plant-animal interactions. While it is encouraging that this study helped in enacting a ban on fig tree lopping in the Sanctuary, it is imperative that this policy be enforced on a consistent basis. Also, forest management training programs at state and national levels must incorporate and stress the importance of conservation of fig trees in maintenance of wildlife populations.

This case can be an example of positive conservation work that can be accomplished when scientists and local forest departments work cooperatively.

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27. THREE NEW ADDITIONS TO THE NON-INDIGENOUS FLORA OF ANDAMAN ISLANDS, INDIA[1]

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During a botanical exploration in the Little Andaman Island, the authors collected three plant species, which have been identified as *Pentapetes phoenicea* L. (Sterculiaceae), *Asclepias currasavica* L. (Asclepiadaceae), and *Acorus calamus* L. (Araceae). The literature on the floristics of Andaman and Nicobar Islands shows that occurrence of these taxa from the union territory has not been reported earlier (Vasudeva Rao 1986; Mathew 1998). The present communication gives a current nomenclature, brief description, distribution and ecology.

Pentapetes phoenicea L., Sp. Pl: 698. 1753; Mast. in Hook.f., Fl. Brit. India 1: 371. 1874; Ridl., Fl. Mal. Pen. 1: 284. 1922; C. Phengklai, Fl. Thai. 7(3): 595. 2001. *P. angustifolia* Bl., Bijdr.: 87. 1825.

Annual herb, *c.* 80 cm high. Leaves simple, narrowly lanceolate, 3.0-14.0 x 0.5-1.5 cm, apex acuminate, base obtuse, margin serrate to serrulate. Flowers pink. Sepals 5, narrowly triangular. Petals bowl-shaped. Stamens in 5 groups; staminodes 5, inserted between the group of stamens, both surrounding the ovary. Ovary ovoid, hairy, 5-locular.

Fl. & Fr.: October-December.

Distribution: India, China and Malay Peninsula.

Ecology: Rare in wet areas.

Specimens Examined: Little Andaman Island, 40 m above msl, R.K. Pur, L. Rasingam, 19848 (PBL).

Asclepias curassavica L., Sp. Pl. 265. 1753; Hook.f., Fl. Brit. India 4: 18. 1883; Jagtap & Singh, Fasc. Fl. India 24: 6. 1999.

Herb, *c.* 1 m high. Leaves opposite, decussate, linear-lanceolate to lanceolate, 5.0-15.0 x 0.7-3.5 cm. Petioles terete, 3-10 mm long. Flowers in 8-10 flowered umbellate cymes, bright crimson; peduncles terete, 1-6 cm long.

Fl. & Fr.: Throughout the year.

Distribution: A native of West Indies and naturalized throughout India.

Ecology: Occasionally found along the roadsides.

Specimens Examined: Little Andaman Island, Krishna Nallah, 50 m, L. Rasingam, 19856 (PBL).

Acorus calamus L., Sp. Pl. 324. 1753; Roxb. Fl. Ind. 2: 169. 1832; Hook.f. Fl. Brit. India 6: 555. 1893; C. Fischer, Fl. Madras 3: 1577(1100). 1931; Mathew, Fl. Tamil Nadu Carnatic 3: 1686. 1983.

Herb, *c.* 1 m high, rhizome aromatic, to 2 cm diameter. Leaves about 80 x 2 cm. Peduncle 25-30 x 1 cm. Spathe leaf-like, 35 x 40 cm long; spadix 5-8 cm long. Flowers densely arranged Tepals glabrous, oblong. Ovary with stigma sessile.

Fl. & Fr.: November-February.

Distribution: Throughout India.

Ecology: Very rare in the swampy areas of littoral forest.

Specimens Examined: Little Andaman Island, Hut Bay, Sea level, L. Rasingam, 19897 (PBL).

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